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BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

IN THE MATTER OF THE DESIGNATION
OF KILAUEA MIDDLE EAST RIFT
ISLAND OF HAWAII, AS A GEOTHERMAL
RESOURCE SUBZONE

GS NO. 9/26/85-5

PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW AND MEMORANDUM OF LAW OF INTERVENORS RALPH PALIKAPU O' KAMOHOALI'I DEDMAN AND DR. NOA EMMETT AUWAE ALULI

I. INTRODUCTION

COME NOW intervenors Ralph Palikapu O' Kamohoali'i Dedman and Noa Emmett Auwae Aluli, by and through their counsel, Thomas E. Luebben, and hereby submit their proposed findings of fact and conclusions of law in the above captioned case.

The following abbreviations are used herein: "VCA" for Volcano Community Association, et al.; "BLNR" for Board of Land and Natural Resources; and "DOWALD" for Division of Water and Land Development.

A. DOWALD'S Proposal and Any Decision by the BLNR to Designate a Geothermal Subzone is Necessarily Arbitrary and Capricious

DOWALD's proposal to designate in excess of 11,000 acres in the Middle East Rift Zone of Kilauea, County of Hawaii, is arbitrary and capricious and is not based upon an "acceptable balance" among the factors required to be considered in the designation of a geothermal subzone by Hawaii Act No. 296 and by the Administrative Rules for the Designation of Geothermal Subzones adopted by the BLNR.

The decision by DOWALD to propose a geothermal subzone in the Middle East Rift Zone, and any decision the BLNR may make in this proceeding to designate a geothermal subzone in the Middle East Rift Zone is per se arbitrary and capricious, and a violation of the right of intervenors to due process of law and the equal protection of the laws under the 14th Amendment to the United States Constitution, because the BLNR has failed to promulgate any meaningful rules or standards whatsoever to govern its decision-making with respect to geothermal subzones. Under the BLNR rules as they now exist, DOWALD may propose the designation of a geothermal subzone and the BLNR may designate a geothermal subzone on the basis of an "acceptable balance" among the considerations listed in §205 of the Hawaii Act No. 296. In practice, the standard of an "acceptable balance" among the factors is absolutely meaningless and allows the BLNR to designate a geothermal subzone without any actual analysis or substantive justification. This proceeding should be suspended and no decision should be made with respect to the designation of a geothermal subzone in the Middle East Rift Zone of Kilauea until the BLNR has promulgated new rules containing meaningful standards for decision-making on geothermal subzones.

Intervenors' Motion to Suspend Hearing Pending Rule-Making, filed with the BLNR at Hilo, Hawaii on November 13, 1985, should be reconsidered and granted by the BLNR.

B. DOWALD'S proposal to Designate the Kilauea Middle East Rift Zone as a Geothermal Subzone Was Made Without Meaningful Standards or Analysis.

The testimony of Mr. Manabu Tagamori, Chief Administrator of DOWALD, clearly revealed that DOWALD's decision to propose the designation of a geothermal subzone in the Middle East Rift Zone of Kilauea was either entirely political or was a response which DOWALD believed was required of DOWALD by the BLNR's previous order in the Kahauale'a Geothermal Subzone proceeding. Mr. Manabu Tagamori's testimony clearly revealed that DOWALD engaged in no meaningful analysis whatsoever of the available information relating to the considerations required by Hawaii Act. No. 296. Mr. Manabu Tagamori was utterly unable to identify any substantive aspect of his decision-making or analytical process. He was only able to say that DOWALD's examination of available information revealed an "acceptable balance" among the factors required to be considered. DOWALD's decision to propose the Middle East Rift Geothermal Subzone was, at best, entirely subjective, and, at worst, made in the face of overwhelming information indicating that, pursuant to the factors mandated by Hawaii Act No. 296, the area should not be so designated. DOWALD found an acceptable balance despite uncontroverted evidence that 1) no present need for the development of geothermal power in the

Kilauea Middle East Rift Zone exists, 2) more than sufficient geothermal electric generating capacity is available from the existing geothermal subzones of Kapoho and Kamaili to meet forseeable needs in the County of Hawaii, 3) geothermal exploration and development will constitute an impermissible burden on the practice of Nataive Hawaiian religion, 4) there will be an adverse impact on essential habitat for the endangered bird O'u, 5) there is strong opposition to the proposed geothermal subzone designation from a broad spectrum of area residents, local community organizations, and local and national conservation organizations, 6) there will be demonstrable and significant negative impact on unique ecological, biological and conservation values now being protected by the current designation of the area as a natural area reserve, and 7) adequate information about social and economic impacts of geothermal energy development in excess of 25 megawatts has not been developed.

C. <u>BLNR Procedures Have Violated Intervenors' Constitutional Right to Due Process</u>

The failure of the BLNR to make a conclusive decision on the status of intervenors Mr. Dedman and Dr. Aluli as either parties or intervenors in the contested case hearing until the opening of the contested case hearing on November 13, 1985 in Hilo, Hawaii, constituted a deprivation of the intervenors' right to due process of law.

Dr. Noa Emmett Auwae Aluli and Palikapu o' Kamohoali'i

Dedman timely filed a petition as parties for a contested case hearing in this matter. On October 17, 1985, Mr. Susumu Ono, Chairperson of the Board of Land and Natural Resources, denied Mr. Dedman's and Dr. Aluli's petition for a contested case hearing, but notified them that their petition would be treated as an application to intervene. Despite the efforts of the intervenors Mr. Dedman and Dr. Aluli to obtain a ruling from the BLNR prior to the commencement of the contested case hearing on November 13, 1985, no such ruling was forthcoming. Consequently, the intervenors were unable to either appeal an adverse decision on their status, or to prepare adequately as intervenors for the contested case hearing.

By letter of November 1, 1985, the intervenors Mr. Dedman and Dr. Aluli formally requested a continuation of scheduled prehearing conferences and the contested case hearing itself to allow time for the BLNR to rule on their status as intervenors and to allow time to prepare for the hearing. This request for a continuance was denied. This course of action by the BLNR effectively denied the intervenors due process of law as guaranteed by the 14th Amendment to the United States Constitution.

D. <u>This Proceeding Should be Dismissed, or the Proposal Should be Denied</u>.

For the above reasons, and based upon the Proposed Findings of Fact and Conclusions of Law contained herein, this proceeding should be dismissed in its entirety, or, in the alternative, DOWALD's proposal for geothermal subzone designation for the Kilauea Middle East Rift Zone should be denied in its entirety.

II. PROPOSED FINDINGS OF FACT.

A. Proposed Findings of Fact as to Intervenors' Claim of Interference with Their Constitutionally Protected Right to Free Exercise of Religion.

1. Pele is one of the most important gods known to Native Hawaiian religion, and is the heart and the life of Native Hawaiian religious beliefs. Intervenors' Ex.2.

2. Thousans of Native Hawaiian people are practitioners of Native Hawaiian religion and are worshippers of the god Pele. See oral testimony of Dr. Aluli, Tr., Vol. VI, p. 16-17.

3. Pele's abode, or home, is understood by Pele religious practitioners to be the general area of volcanic activity on the island of Hawaii, extending from Mauna Loa through the Ka'u and Puna districts to the Pacific Ocean, and including the entire area of Kilauea Volcano and the East and Southwest Rift Zones. Oral tesimony of Dr. Aluli, Tr., Vol. VI, p. 10, 12-13.

4. The area known to Pele practitioners as Pele's abode, or home, is considered a sacred area. Oral testimony of Dr. Aluli, Tr., Vol. VI, p. 10.

5. Certain activities are considered impermissible by Pele practitioners within the area of Pele's abode, or home.

Such activities are considered to be an offense to Pele, and a desecration of her body and being. Oral testimony of Mr. Dedman, Tr., Vol. V, p. 140-141.

6. Geothermal exploration and development is considered by Pele practitioners to be an offense against Pele and a desecration of her body and being because it involves drilling into Pele's body and removing her very energy. Oral testimony of Dr. Aluli, Tr., Vol. VI, p. 16.

7. In the view of Pele religious practitioners, geothermal exploration and development will actually take and kill Pele forever. Orall testimony of Dr. Aluli, Tr., Vol. VI, p. 26.

8. The area of active volcanism on the island of Hawaii is considered by Pele practitioners to be Pele's physical body. Oral testimony of Dr. Aluli, Tr., Vol. VI, p. 10-11.

9. The geothermal resource is usually associated with the presence of fluid magma beneath the earth's surface. Oral testimony of Dr. Thomas, Tr., Vol. IV, p. 175

10. The presence of magma indicates the actual presence of Pele in that area. Oral testimony of Dr. Aluli, Tr., Vol. VI, p. 10-11.

11. Native Hawaiians and Pele practitioners believe that offenses against Pele, and desecrations of her sacred body, such as geothermal exploration and development, will cause Pele to retaliate violently in the form of volcanic eruptions, earthquakes and tsunamis. Native Hawaiians and Pele

practitioners fear for the loss of their lives and the lives of their children. Oral testimony of Mr. Dedman, Tr., Vol. V, p. 141-142.

12. Pele is central and indispensable to Native Hawaiian religious beliefs and practices. Oral testimony of Dr. Aluli, Tr., Vol. VI, p. 19.

13. Pele is present and seen in the sacred area surrounding Kilauea Volcano in kino lau, or alternate body forms, which include the fern, certain shrubs, certain native trees, and certain volcanic land forms. These plants, as kino lau, and the various significant land forms, as kino lau, such as Pu'u, are sacred. Intervenors' Ex. 2.

14. Pele is a living god, whose presence is manifested in periodic and frequent volcanic eruptions. Intervenors' Ex. 2.

15. Pele is Kupuna and Tutu to Pele practitioners. As such, Pele as a spiritual concept and experience is central to their lives and psychological survival. Pele is also Akua and Aumakua of Pele practitioners. Intervenors' Ex. 2.

16. Pele provides inspiration, strength, and focus for the lives of Pele practitioners. Intervenors' Ex. 2.

17. Because it represents to Pele practitioners an actual, physical degradation and violation of Pele's body, geothermal exploration and development will threaten and probably prevent the continuation of all essential ritual practices with respect to Pele, and therefore impair the ability of Pele

practitioners to train young persons in traditional Hawaiian and Pele religious beliefs and practices. This means that Native Hawaiian religion and culture will not be conveyed to future generations and will die. Intervenors' Ex. 2.

18. Pele influences and informs the daily physical and spiritual life of Pele practitioners. It is essential to them that Pele not be violated and degraded, and that she be allowed to exist in her unaltered form and in a pristine natural environment.

19. In volcanic eruptions, Pele is the heat, the water and steam, and the smoke or vapor. Intervenors' Ex. 2.

20. Pele is the creator and the embodiment of the creation process. Pele represents the cosmic creation process as actually seen in a volcanic eruption. Intervenors' Ex. 2.

21. Geothermal exploration and development will diminish and finally destroy Pele's creative force. This will cause spiritual, cultural, psychological and sociological injury to the people who worship and respect Pele. Intervenors' Ex. 2.

22. The "renewable geothermal resource" in the Kilauea area is only 50 megawatts annually. Production of geothermal energy in excess of 50 megawatts annually will constitute energy mining, and will physically diminish the amount of heat energy present in the Kilauea active volcanic system. Written testimony of Dr. Robert Decker, VCA, Ex. 216, p. 5 from CDUA contested case hearing No. HA- 3/2/82-1463.

23. To the Pele practitioners, geothermal energy

production constitutes an actual, physical diminishment of Pele's energy and hence her spiritual power. It will diminish her vitality so that she will no longer respond to her people's prayers.

24. Geothermal exploration and development will personally injure the sacred body of the god Pele. Intervenors' Ex. 2.

25. Violation and desecration of the sacred body of the god Pele, as Pele practitioners believe will occur with geothermal exploration and development, will destroy the relationship and communication which Pele practitioners have with the god Pele.

26. Geothermal energy production will withdraw Pele's energy, and literally diminish and eventually deplete her creative force.

B. <u>Proposed Findings of Fact Relating to the Need for Geothermal Energy Development on the Island of Hawaii.</u>

27. Electrical power needs on the island of Hawaii are stable, and the demand for geothermal electrical energy on the island of Hawaii is limited. Testimony of Manabu Tagamori, Tr., Vol. _ pp. 77-78.

28. The Hawaii Electric Light Company is seeking only 13 megawatts of geothermal generating capacity on the Island of Hawai. This will meet the forseeable needs of Hawaii Electric Light Company for the Island of Hawaii through at least 1989. Oral testimony of Alva Nakamura, Tr. Vol. IV, p.104-05.

29. The 13 megawatts of geothermal generating capacity referred to above would be used to replace biomass generating capacity from Puna in the event that Puna is not able to renew its contract. It is not known at this time whether Puna will or will not renew. Oral testimony of Alva Nakamura, Tr., Vol. IV, p. 112.

30. The Hawaii Electric Light Company has signed contracts with wind developers to provide in excess of 20 megawatts of new electric generating capacity. Oral testimony of Alva Nakamura, Tr. Vol. IV., p. 112.

31. The Hawaii Electric Light Company does not plan to replace its existing diesel electric power generating capacity. Oral testimony of Alva Nakamura, Tr., Vol. IV, p. 110.

32. The Hawaii Electric Light Company actually requires only 8.25 megawatts of additional generating capacity through the year 1989. This electric generating capacity can be provided by three diesel generating units. Oral testimony of Alva Nakamura, Tr. Vol. IV, p. 120.

33. The use of geothermal electric generating capacity will not reduce the cost of electric energy to consumers. Oral testimony of Alva Nakamura, Tr., Vol. IV, p. 132.

34. Present and future needs of the Island of Hawaii can be met by Hawaii Electric Light Company from diesel, wind, hydro and biomass electric generating capacity for the forseeable

future. Oral testimony of Alva Nakamura, Tr., Vol. IV, p. 132.

C. Proposed Findings of Fact with Respect to DOWALD's Decision to Propose a Geothermal Subzone for the Middle East Rift Zone..

35. DOWALD was aware at the time it proposed geothermal subzone designation for the Middle East Rift Zone that Native Hawaiian Pele practitioners consider the lands proposed for geothermal subzone designation to be sacred and both the physical body and abode of their god Pele. These practitioners consider their connection and communication with Pele to be essential to the successful conduct of their daily life activities. These people also believe that geothermal development may forever extinguish or destroy essential parts of Hawaiian heritage, culture and religion, and that Pele disapproves, is offended, and may retaliate in ways that would harm them or their families. Oral testimony of Manabu Tagamori, Tr., Vol. III, p. 7-9.

36. DOWALD arbitrarily discounted the information that geothermal exploration and development will interfere with, and even destroy, the Pele religion and certain aspects of Hawaiian culture on the principle grounds that 1) Native Hawaiians and Pele practitioners do not object to geothermal exploration and development because ancient Hawaiians used naturally occurring steam vents and fumarols to cook food for ritual (religious) use and 2) certain individual Native Hawaiians do not oppose geothermal exploration and development. Oral

testimony of Manabu Tagamori, Tr., Vol. III, p. 12-13, Tr., Vol. IV, p. 96-97, DOWALD Exhibit No. 10.

37. The only guidelines used by DOWALD to determine whether it should propose a geothermal subzone for the Middle East Rift Zone were Hawaii Acts Nos. 296 and 151, and the DLNR Administrative rule in subzoning. Oral testimony of Manabu Tagamori, Tr., Vol. III, p. 64-66.

38. DOWALD did not attempt to determine how much electrical energy could be supplied from the Kapoho and Kamaili geothermal subzones before recommending geothermal subzone designation for the Middle East Rift Zone. Oral testimony of Manabu Tagamori, Tr., Vol. III, p. 77-78.

39. DOWALD decided to recommend geothermal subzone designation for the Middle East Rift Zone on the basis of certain assumptions, apparently different from the seven criteria set forth in Hawaii Act. No. 296, and on the basis of certain mandates, also apparently different from the seven criteria provided in the Act. Oral testimony of Manabu Tagamori, Tr., Vol. I, p. 107.

40. In determining whether to propose a geothermal subzone designation for the Middle East Rift Zone, DOWALD arbitrarily discounted adverse public comments simply on the basis of the fact that there were favorable public comments. Oral testimony of Manabu Tagamori, Tr., Vol. I, p. 56-57 .

41. In determining the compatibility of the proposed geothermal subzone designation with existing land uses in the

area, as required by Hawaii Act No. 296, DOWALD did not consider the fact that the area has already been designated a natural area reserve. Instead, DOWALD believed it had a mandate from the BLNR to propose the Middle East Rift Zone for geothermal subzone designation. Oral testimony of Manabu Tagamori, Tr., Vol. I, p. 106.

42. DOWALD did not originally propose the Middle East Rift Zone for geothermal subzone designation because of its status as a natural area reserve. DOWALD provided no reason consistent with the seven criteria mandated by Hawaii Act No. 296 why it changed its earlier opinion and proposed the Middle East Rift Zone for geothermal subzone designation. Oral testimony of Manabu Tagamori, Tr., Vol. I, p. 104-105.

43. The sole reason for DOWALD's proposal that the Middle East Rift Zone be designated a geothermal subzone was the decision and order of the board in the Kahaualea Geothermal Subzone Proceeding. Oral testimony of Manabu Tagamori, Tr., Vol. I, p. 105.

44. No specific weight was given by DOWALD to any of the considerations mandated by Hawaii Act. No. 296 for the decision to designate a geothermal subzone. Oral testimony of Manabu Tagamori, Tr., Vol. II, p. 114.

45. DOWALD weighed the seven factors listed in Hawaii Act No. 296 in originally determining not to recommend the Middle East Rift Zone for geothermal subzone designation. Oral testimony of Manabu Tagamori, Tr., Vol. II, p. 116.

46. Despite the fact that DOWALD possessed uncontroverted evidence that designation of the Middle East Rift Zone as a geothermal subzone will interfere with religious beliefs and activities which are central and indispensable to the practice of Native Hawaiian religion, and despite the fact that the social consideration portion of §205 (b)(4) of Hawaii Act No. 296 (which includes religion) was not considered by DOWALD to be less important than any other factors to be considered under §205 of Act No. 296, DOWALD arbitrarily proposed the Middle East Rift Zone for geothermal subzone designation. Oral testimony of Manabu Tagamori, Tr., Vol. II, p. 119-121.

47. The potential social and economic impact of designating the Middle East Rift Zone as a geothermal subzone were studied under contract to DOWALD only for geothermal production from the subzone of up to 30 megawatts. Oral testimony of Bee Yee, Tr., Vol. I, p. 22, p. 127-128, p. 138-139.

48. An appropriate assessment or determination of an "acceptable balance" among the seven criteria for geothermal subzone designation set forth in §205 of Hawaii Act No. 296 was possible with respect to the Middle East Rift Zone because the full social and economic impact of the geothermal subzone designation was not assessed. Oral testimony of Yee, Tr., Vol. I, p. 122-123, p. 127-128.

49. No meaningful analysis of the seven factors required to be considered pursuant to Hawaii Act No. 296 in determining whether to propose a geothermal subzone designation

was undertaken by DOWALD prior to its decision to propose the Middle East Rift Zone for geothermal subzone designation. No meaningful standards of decision making were applied, and the decision is best characterized as arbitrary and capricious. Oral testimony of Manabu Tagamori, Tr., Vol. III, p. 25-27; Tr., Vol. II, p. 113-123.

D. Additional Proposed Findings of Fact Adopted by Reference.

Intervenors hereby adopt the following proposed findings of fact from the brief of the Volcano Community Association, et al.:

Nos. 1-17

Nos. 32-55

III. PROPOSED CONCLUSIONS OF LAW

A. Intervenors' Proposed Conclusions of Law.

1. DOWALD did not make a meaningful or adequate assessment or analysis of the factors required by Hawaii Act No. 296 to be considered in determining whether to propose in excess of 11,000 acres in the Middle East Rift Zone as a geothermal subzone.

2. The proposed Middle East Rift Zone geothermal subzone does not demonstrate an "acceptable balance" among the factors required by Hawaii Act No. 296 to be considered by the BLNR in designating a geothermal subzone.

3. There is no need to designate any part of the

Kilauea Middle East Rift Zone as a geothermal subzone at the present time because current projections of future electric power needs of the County of Hawaii are no more than 13 megawatts through 1989, which need can be satisfied by non-geothermal methods of electric power generation or by the previously designated Kapoho and Kamaili Geothermal Subzones.

4. The First Amendment right to the free exercise of religion of the intervenors Mr. Dedman and Dr. Aluli will be impermissibly burdened by exploration for or development of geothermal resources within any part of the area proposed by DOWALD as a geothermal subzone in the Middle East Rift Zone of Kilauea.

5. DOWALD has failed to show any compelling or overriding state interest in the designation of any part of the Middle East Rift Zone of Kilauea as a geothermal subzone which will justify the burden upon the intervenors Mr. Dedman's and Dr. Aluli's First Amendment right to the free exercise of their Pele religion.

6. The religious beliefs of the intervenors Mr. Dedman and Dr. Aluli in the Native Hawaiian god Pele is deeply rooted in the ancient and traditional Native Hawaiian religion.

7. The Native Hawaiian religious beliefs and practices of the intervenors Mr. Dedman and Dr. Aluli which will be infringed by geothermal exploration and development in any part of the Kilauea Middle East Rift Zone are central and indispensable to the practice of their religion.

8. Any overriding or compelling interest which the State of Hawaii may have in the designation of any part of the Middle East Rift Zone of Kilauea as a geothermal subzone can be satisfied by alternative means, namely, by utilization of electric energy production from diesel power plants, wind farms, biomass fuel or hydropower, or by energy conservation.

B. Additional Proposed Conclusions of Law Adopted by Intervenors by Reference.

Intervenors Mr. Dedman and Dr. Aluli hereby incorporate by reference the proposed conclusions of law Nos. 1-11 of the Volcano Community Association, et al.

Respectfully submitted,

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IN THE SUPREME COURT OF THE STATE OF HAWAII

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RALPH PALIKAPU O'KAMOHOALII DEDMAN and DR. NOA EMMETT AUWAE ALULI, Intervenors-Appellants, and VOLCANO COMMUNITY ASSOCIATION, et al., Petitioners, vs. BOARD OF LAND AND NATURAL RESOURCES, et al., Appellees.

NO. 11126

APPEAL FROM BOARD OF LAND AND NATURAL RESOURCES

(G.S. NO. 9/26/85-5)

AND

RALPH PALIKAPU O'KAMOHOALII DEDMAN and DR. NOA EMMETT AUWAE ALULI, Petitioners-Appellants, and LEHUA LOPEZ, et al., Petitioners, vs. BOARD OF LAND AND NATURAL RESOURCES, et al., Appellees.

NO. 11334

APPEAL FROM BOARD OF LAND AND NATURAL RESOURCES

(CDUA NO. HA-12/20/85-1830)

JULY 14, 1987

LUM, C.J., NAKAMURA, PADGETT, HAYASHI, JJ. and INTERMEDIATE COURT OF APPEALS ASSOCIATE JUDGE HEEN IN PLACE OF WAKATSUKI, J., EXCUSED

CONSTITUTIONAL LAW -- personal, civil and political rights -- religious liberty and freedom of conscience -- in general.

In order to find an unconstitutional infringement on religious practices, it is necessary to examine whether or not the activity interfered with by the state was motivated by and rooted in a legitimate and sincerely held religious belief, whether or not claimants' free exercise of religion is burdened by the regulation, the extent or impact of the regulation on the parties' religious practices, and whether or not the state has a compelling interest in the regulation which justified such a burden.

CONSTITUTIONAL LAW -- personal, civil and political rights -- religious liberty and freedom of conscience -- particular matters and applications -- zoning and land use.

Designation of an area as a geothermal resource subzone and approval of specific geothermal development plans do not infringe on claimants' freedom to exercise their religion where it is undisputed that claimants never used the land for religious purposes and have presented no objective evidence of harm to religious practices.

ADMINISTRATIVE LAW -- powers and proceedings of administrative agencies, officers and agents -- hearings and adjudications -- findings.

SAME -- same -- same -- conclusions.

Hawaii Revised Statues § 91-12 (1985) requires an agency to rule upon proposed findings, but a separate ruling on each proposed finding filed by a party is not indispensable. The statute only requires that the parties not be left to guess, with respect to any material questions of fact, or to any group of minor matters that may have cumulative significance, the precise findings of the agency.

ADMINISTRATIVE LAW -- judicial review of administrative decisions -- scope of review in general -- burden of showing error.

An agency's findings are presumptively correct, and cannot be set aside on appeal unless they are shown to be clearly erroneous in view of the reliable, probative and substantial evidence of the record as a whole.

OPINION OF THE COURT BY LUM, C.J.

I.

This appeal presents us with various challenges to the approval of the development of geothermal energy in the Kilauea Middle East Rift Zone ("KMERZ") on the island of Hawaii. The two separate appeals taken from the decisions of the Board of Land and Natural Resources ("Board") were consolidated at oral argument as they present similar facts and issues to this court. Hawaii Rules of Appellate Procedure 3(b).

Both cases challenge the decision to permit geothermal energy development in the KMERZ area on the ground that it violates Appellants' right to freely exercise their religion. In No. 11126, Appellants also allege the Board failed to adequately consider their religious claims in weighing the criteria for establishing a geothermal resource subzone under Hawaii Revised Statutes ("HRS") § 205-5.2(d)(3) (1985).

Other errors alleged on appeal concern the designation of the area as a geothermal resource subzone and the grant of a permit to develop a 25 megawatt ("MeW") geothermal generator with exploration for development of another 75 MeW of geothermal energy in the future.

We affirm.

II.

In 1983 the Hawaii legislature passed the Geothermal Energy Act which granted the Board of Land and Natural Resources primary responsibility for establishing geothermal resource zones within the state. Act 296, § 3, 1983 Haw. Sess. Laws 638, codified at HRS § 205.2(a) (1985). Once the Board has established such zones, if the project falls within an area zoned conservation land, as in the present case, then the Board has jurisdiction to approve the project. Act 151, § 2, 1984 Haw. Sess. Laws 279, codified at HRS § 205-5.1 (d) (1985).

In the present case, Appellees The Estate of James Campbell and True/Mid-Pacific Geothermal Ventures (collectively "Campbell") applied for a conservation district use permit in the Kahauale'a area on March 2, 1982. Over the next year, the Board received the environmental impact statement on the application and conducted contested case hearings concerning this matter. On February 25, 1983, the Board heard oral argument on the application, propounded its findings of fact and conclusions of law, and rendered its Decision and Order ("February 25, 1983 Decision"). The February 25, 1983 Decision granted Campbell the permit with 43 conditions on exploration and development of baseline activities.

In June of 1983, volcanic eruptions in the Kahauale'a area caused some question as to the safety of tapping geothermal resources in the specific site approved. In May of 1984, the Board proposed administrative rules concerning hearings on the designation and regulation of geothermal resource subzones. Also in May of 1984, the legislature passed Act 151, which mandated the Board to assess the February 25, 1983 Decision regarding the Kahauale'a area as a geothermal resource subzone. 1984 Haw. Sess. Laws § 3, at 281. In July, the Board's administrative rules concerning geothermal subzones were adopted, and in August they were amended.

Throughout 1984, various public and contested case hearings were held around the island of Hawaii concerning designation of the Kahauale'a area as a subzone. On December 28, 1984, the Board issued its preliminary Decision and Order approving the designation of the Kahauale'a area as a geothermal subzone ("December 28, 1984 Decision"). The decision instructed Campbell to explore the possibility of a land swap wherein the Kahauale'a land, which is situated adjacent to Volcano National Park, would be exchanged for land in the Wao Kele 'O Puna Natural Area Reserve (to the east) in the KMERZ. On August 10, 1984, Campbell applied for a conservation district use permit to develop 100 MeW of geothermally generated electricity in the KMERZ.

During much of 1985 more public and contested case hearings were held on designation of the KMERZ as a geothermal resource subzone. In October of 1985, the Board amended the December 28, 1984 Decision and approved the land swap but included an area to be later given to the nearby national park.

In November of 1985, Appellants were granted intervenor status in the scheduled contested case hearings concerning the approval of the KMERZ area as a geothermal resource subzone. The hearings were held from November 13 to 15 in Hilo. On December 20, 1985, the Board issued its Decision and Order, and on April 9, 1985, it issued findings of fact and conclusions of law ("April 9, 1985 Decision") approving of 9,014 acres as a geothermal resource subzone.

On December 27, 1985, the State and Campbell Estate exchanged deeds, the State receiving the Kahauale'a land and Campbell Estate receiving a portion of the KMERZ area. The State reserved, however, mineral rights, including the underground steam, and required Campbell Estate "covenant that the use and enjoyment of the land conveyed shall not be in support of any policy which discriminates against anyone based upon race, creed, color or national origin." See HRS § 171-64 (1985).

The Board accepted Campbell's application for a conservation district use permit on January 3, 1986 and required that they complete an environmental impact statement on the proposed action. A public hearing on the application was heard on January 13, 1986, at which time a contested case hearing was requested. Contested cases hearings were held from February 18 to 23, 1986 and on March 14, 1986. The Board issued its Decision and Order on April 11, 1986 later amended by the findings of fact and conclusions of law filed June 18, 1986 ("June 18, 1986 Decision"). The June 18, 1986 Decision permits Campbell to explore, develop, and produce up to 25 MeW of geothermal energy, and allows Campbell to explore for the future development of an additional 75 MeW, all subject to compliance with conditions on archaeological sites and air, water, land, noise, and light pollution monitoring.

Defendants subsequently filed a motion to appeal to this court. The Board granted Appellants' motion on September 28, 1986.[1]

III.

Appellants' religious claims with regard to both the designation of a geothermal resource subzone and the granting of the permit are essentially the same. Hence, this issue is treated immediately below. Challenges to the Board's exercise of discretion involve separate issues and are treated separately for each appeal in section IV.

Appellants' main contention on appeal is that the approval of the geothermal project will infringe on their religious practices as "Pele practitioners." According to Appellant Aluli, the goddess[2] Pele migrated to the Northwestern Hawaiian Islands from Tahiti. She then moved down the island chain until she reached the island of Hawaii where she lives today. Areas in the island chain where she attempted to establish herself are considered sacred. Appellant Aluli identified as especially sacred the area "from Moku'aweoweo [the top of], Mauna Loa, all

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1 In 1985, the legislature provided for appeals directly to the supreme court from decisions of the Board approving a project within the resource subzone. Act 226, § 1, 1985 Haw. Sess. Laws 414, codified at HRS § 205-5.1(f) (1985). Jurisdiction over the present appeal is based on this subsection.

2 According to Appellants, Pele is considered either an akua (god) or an aumakua (family or personal god). This distinction has significance insofar as one witness considered Pele as an aumakua, and worshipped Pele in her home.

the way down including these areas from Puna to Ka'u" on the southeastern portion of the island. Phenomena associated with the volcanic activity, i.e., heat, steam, magma, as well as the surrounding landscape, i.e., ferns, shrubs, land and even the rain, are also considered sacred. Development of geothermal resources in the area, Appellants contend, will impinge on their right to freely exercise their religion as guaranteed under the first amendment to the United States Constitution[3] and article I, section 4 of the Hawaii Constitution.[4]

In order to find an unconstitutional infringement on Appellants' religious practices,

> it [is] necessary to examine whether or not the activity interfered with by the state was motivated by and rooted in a legitimate and sincerely held religious belief, whether or not the parties' free exercise of religion had been burdened by the regulation, the extent or impact of the regulation on the parties' religious practices, and whether or not the state had a compelling interest in the regulation which justified such a burden.

State ex rel. Minami v. Andrews, 65 Haw. 289, 291, 651 P.2d 473, 474 (1982). Accord Wisconsin v. Yoder, 406 U.S. 205 (1972). Moreover, the United States Supreme Court has "long recognized a distinction between the freedom of individual belief, which is absolute, and the freedom of individual conduct, which is not

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3 This amendment reads in part: "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof[.]" U.S. Const. amend. I.

4 This section provides in part: "No law shall be enacted respecting an establishment of religion, or prohibiting the free exercise thereof[.]" Haw. Const. art. I, § 4.

absolute." Bowen v. Roy, 476 U.S. ___, ___, 106 S. Ct. 2147, 2152, 90 L. Ed. 2d 735, 744 (1986). See Braunfeld v. Brown, 366 U.S. 599, 603 (1961); Reynolds v. United States, 98 U.S. (8 Otto) 145 (1879). Accord Koolau Baptist Church, 68 Haw. ___, ___, 718 P.2d 267, 271 (1986).

Neither the Board nor Campbell questions the legitimacy and sincerity of Appellants' religious claims. We therefore turn to the issue of whether or not the parties' free exercise of religion had been burdened by the regulation, and the extent or impact of the regulation on the parties' religious practices.

As a preliminary matter, "it is necessary in a free exercise case for one to show the coercive effect of the [law] as it operates against him in the practice of his religion." School District of Abington Township v. Schempp, 374 U.S. 203, 223 (1963). Accord Thomas v. Review Board, Indiana Employment Security Division, 450 U.S. 707, 717-18 (1981); Koolau Baptist Church v. Department of Labor, 68 Haw. at ___, 718 P.2d at 272 (1986). Appellants' assert this burden through testimony that construction of geothermal energy plants will desecrate the body of Pele by digging into the ground and will destroy the goddess by robbing her of vital heat. They claim this will interfere with their ritual practices, and will disable them from training young Hawaiians in traditional beliefs and practices (e.g., chant and hula). As such, approval of the geothermal plant does not regulate or directly burden Appellants' religious beliefs,[5] nor inhibit religious speech.[6] Further, the Board's action does not compel them, by threat of sanctions, to refrain from religiously motivated conduct[7] or engage in conduct they find objectionable on religious grounds.[8] See Bowen, 476 U.S. at ___, 106 S. Ct. at 2153-54, 90 L. Ed. 2d at 746 (plurality opinion); Braunfeld, 366 U.S. at 603.

Rather, Appellants assert an infringement on their religious practices. In order to demonstrate the coercive effect of the geothermal project, Appellants must show a "substantial burden" on religious interests. Koolau, 68 Haw. at ___, 718 P.2d

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5 Estate of Thornton v. Caldor, Inc., 472 U.S. 703 (1985); Tony and Susan Alamo Foundation v. Secretary of Labor, 471 U.S. 290 (1985); Follet v. Town of McCormick, 321 U.S. 573, 577-78 (1944); Murdock v. Pennsylvania, 319 U.S. 105, 112 (1943).

6 Cf. Widmar v. Vincent, 454 U.S. 263 (1981); Wooley v. Maynard, 430 U.S. 705 (1977); Cantwell v. Connecticut, 310 U.S. 296 (1940).

7 Cf. Goldman v. Weinberger, 475 U.S. 503 (1986); Sherbert v. Verner, 374 U.S. 398 (1963); Braunfeld v. Brown, 366 U.S. 599 (1961); Prince v. Massachusetts, 321 U.S. 158 (1944); Cox v. New Hampshire, 312 U.S. 569 (1941); Pierce v. Society of Sisters, 268 U.S. 510 (1925); Reynolds v. United States, 98 U.S. (8 Otto) 145 (1879).

8 Cf. Hobbie v. Unemployment Appeals Comm'n of Florida, ___ U.S. ___, 107 S. Ct. 1046, 94 L. Ed. 2d 190 (1987); Thomas v. Review Board, Ind. Employment Sec. Div., 450 U.S. 707, 717-18 (1981); United States v. Lee, 455 U.S. 252, 259 (1982); Wisconsin v. Yoder, 406 U.S. 205 (1972); Gillette v. United States, 401 U.S. 437 (1971); Sch. Dist. Abington Township v. Schempp, 374 U.S. 203 (1963); Torcaso v. Watkins, 367 U.S. 488 (1961); West Virginia Bd. of Ed. v. Barnette, 319 U.S. 624 (1943); Jacobson v. Massachusetts, 197 U.S. 11 (1905).

at 272; Wisconsin v. Yoder, 406 U.S. at 218. Yet it is uncontested that "[n]either of the [Appellants] nor any of the witnesses testified that they ever conducted or participated in religious ceremonies on this land." And the Board specifically concluded that "[t]here is no indication that tapping this heat source from the earth has diminished or negatively affected the eruptive nature of Kilauea Volcano." There is simply no showing of "the kind of objective danger to the free exercise of religion that the First Amendment was designed to prevent." Wisconsin v. Yoder, 406 U.S. at 218.

To invalidate the Board's actions based on the mere assertion of harm to religious practices would contravene the fundamental purpose of preventing the state from fostering support of one religion over another.[9] As Judge Learned Hand stated:

> The First amendment . . . gives no one the right to insist that in pursuit of their own interests others must conform their conduct to his own religious necessities. . . . We must accommodate our idiosyncracies, religious as well as secular, to the compromises necessary in communal life[.]

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9 The entire amendment was designed to insulate religious activity from state involvement. See Everson v. Bd. of Education, 330 U.S. 1, 8-10 (1947); Walz v. Tax Comm'n, 397 U.S. 664, 668 (1970); Watson v. Jones, 80 U.S. (13 Wall.) 679, 730 (1871). See generally L. Tribe, American Constitutional Law 814-15 (1978); McCoy, A Unifying Theory for the Religion Clauses of the First Amendment, 39 Vand. L. Rev. 249, 255 & n.20 (1978). The Supreme Court has summarized the purpose behind the free exercise clause thus: "Congress [is] deprived of all legislative power over mere opinion, but [is] left free to reach actions which [are] in violation of social duties or subversive of good order." United States v. Reynolds, 98 U.S. (8 Otto) at 164.

Otten v. Baltimore & Ohio R. Co., 205 F.2d 58, 61 (2d Cir. 1953). Accord Estate of Thornton v. Caldor, Inc., 472 U.S. 703, 710 (1985).

We find no merit to Appellants' claim that the project will substantially burden their religious practices. As the Board stated, "[b]y virtue of the land exchange, the proposed development site will be an additional 5 to 10 miles away from Moku'a'weoweo and Halema'uma'u where tradition suggests Pele to reside." Moving the project away from the volcanic phenomena associated with Pele further accommodates Appellants' religious practices.

The free exercise clauses of the state and federal constitutions are "written in terms of what the government cannot do to the individual, not in terms of what the individual can extract from the government." Sherbert v. Verner, 374 U.S. 398, 412 (1963) (Douglas, J., concurring). Accord Bowen, 476 U.S. at ___, 106 S. Ct. at 2152, 90 L. Ed. 2d at 744. See Crow v. Gullet, 541 F. Supp. 785, 791 (D.S.D. 1982) ("the free exercise clause places a duty upon a state to keep from prohibiting religious acts, not to provide the means or the environment for carrying them out."), aff'd 706 F.2d 856 (8th Cir.) (per curiam), cert. denied sub nom. Fools Crow v. Gullet, 464 U.S. 977 (1983). See also Inupiat Community of Arctic Slope v. United States, 548 F. Supp. 182, 188-89 (D. Alaska 1982), aff'd 746 F.2d 570 (9th Cir. 1984) (per curiam); cert. denied ___ U.S. ___, 106 S. Ct. 68 (1985).

IV.

Appellants' other objections to development of geothermal energy in the area allege errors by the Board peculiar to each of the Board's decisions: designation of a geothermal resource subzone in No. 11126 and permit approval of a geothermal site in No. 11334.

A. Case No. 11126

Appellants assert the Board's procedure in designating the area as a geothermal resource subzone violates due process in that the Board's Administrative Rule § 13-184-6[10] failed to

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10 This rule reads:

> Criteria for the designation of subzones. The board, in designating an area a geothermal resource subzone, shall be guided by the selection of those areas that can demonstrate an acceptable balance among the criteria set forth below:
> (1) That the area has potential for geothermal activities;
> (2) That there is a known or likely prospect for the utilization of geothermal resources for electrial energy production;
> (3) That any potential geologic hazards to geothermal production or use in the proposed area are examined;
> (4) That any environmental or social impacts of the development of geothermal resources within the proposed area be considered;
> (5) That the compatiblity of development and utilization of geothermal resources within the proposed area is considered with other allowed uses within the area and within the surrounding lands; and
> (6) That the potential benefits to be derived

(Footnote Continued)

provide an "ascertainable standard sufficient to meet constitutional requirements," and the Board's delegate, the Department of Water and Land Development ("DOWALD") failed to adequately assess the potential effects of subzoning. They further allege the Board erred in accepting or rejecting their proposed findings concerning the impact of the proposed development on Pele practitioners. We take each issue in turn.

In the past, we have given great deference to an administrative agency's interpretation of its legislative mandate and its own administrative rules. See, e.g., Aio v. Hamada, 66 Haw. 401, 407, 664 P.2d 727, 731 (1983); Treloar v. Swinerton & Walberg Co., 65 Haw. 415, 424, 653 P.2d 420, 426 (1982). "Although administrative convenience or even necessity cannot override the constitutional requirement of due process, . . . agencies 'should be free to fashion their own rules of procedure and to pursue methods of inquiry capable of permitting them to discharge their multitudinous duties.'" Yamada v. Natural Disaster Claims Commission, 54 Haw. 621, 627, 513 P.2d 1001, 1005 (1973) (citation omitted) (quoting F.C.C. v. Pottsville Broadcasting Co., 309 U.S. 134, 143 (1940) (footnote omitted)).

(Footnote Continued)

> from geothermal development and utilization in the proposed area be in the interest of the county or counties involved in the State as a whole.

Administrative Rules of the Department of Land and Natural Resources, § 13-184-6 (1984).

Administrative Rule § 13-184-6 substantially adopts the criteria for establishing a geothermal resources subzone set forth by the legislature in HRS § 205-5.2(b) (1985). The following subsection, HRS § 205-5.2(c), states "[m]ethods for assessing the factors in subsection (b) shall be left to the discretion of the board and may be based on currently available public information." Thus, the statutory scheme explicitly contemplates the Board's use of its discretion in determining the appropriate boundaries for designation of the geothermal resource subzone. We hold the statute is sufficiently clear to comport with due process. Cf. Creative Environments, Inc. v. Estabrook, 680 F.2d 822, 830-31 (1st Cir.) (regulation requiring subdivision plan to be in "best interests of the town" not unconstitutionally vague), cert. denied 459 U.S. 989 (1982); Dillow v. City of Peoria, 49 Ill. 2d 314, ___, 274 N.E.2d 96, 97-98 (1971) (ordinance with purpose to protect "high ratio of home ownership" not vague); Maryland-National Capital Park and Planning Commission v. Mayor and Council of Rockville, 272 Md. 550, ___, 325 A.2d 748, 753-54 (1974) (statute not permitting land use changes "substantially different" not vague).

Appellants also allege the initial assessment done by DOWALD's Manager-Chief Engineer Manbu Tagomori was based on unconstitutionally vague standards. Tagomori testified that the team evaluated the appropriate area based on "personal experience" and "best judgment." The fact that Tagomori's team used these sources in identifying the appropriate area does not invalidate the proposal. This is precisely what the Board was mandated to do. HRS § 205-5.2(c). Moreover, the statute and the relevant administrative rules only require use of the guidelines in evaluating final approval of the subzone. HRS § 205-5.2; Administrative Rules of the Department of Land and Natural Resources, §§ 13-184-2 through 13-184-9. Designation of the subzone was the subject of extensive hearings by the Board in reviewing the various evidence put before it. There is simply no merit to Appellants' claim that they were denied due process.

Appellants' contention that the Board failed to accept or reject certain proposed findings is also without merit. HRS § 91-12 (1985) does require an agency to rule upon proposed findings, but "a separate ruling on each proposed finding filed by a party is not indispensable." In re Hawaiian Telephone Co., 54 Haw. 663, 668, 513 P.2d 1376, 1379 (1973) (quoting In re Terminal Transportation, Inc., 54 Haw. 134, 139, 504 P.2d 1214, 1217 (1972)). It requires that the parties not be left to guess, with respect to any material questions of fact, or to any group of minor matters that may have cumulative significance, the precise findings of the agency. Id.

The Board accepted Appellants' proposed findings of fact 12 and 18, set out in the margin,[11] when it found:

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[11] The proposed findings of fact read:

> 12. Pele is central and indispensable to Native Hawaiian religious beliefs and practices.
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> . . . .

(Footnote Continued)

> 136. . . . Pele is believed to also be present in the sacred area surrounding the Kilauea Volcano in kinolau (alternate body forms) such as ferns, certain shrubs and trees, and certain volcanic land forms or features, such as significant pu'u (hills).
>
> . . . .
>
> 139. . . . There was testimony indicating that Pele is a spiritual concept central to the lives and psychological survival of the believers, and that Pele provides inspiration, strength and a focus for their lives. . . .

Further, the Board rejected findings 21 and 25, also set out in the margin, when it determined that Appellants failed to show sufficient burden on their religious practices.

(Footnote Continued)

> 18. Pele influences and informs the daily physical and spiritual life of Pele practitioners. It is essential to them that Pele not be violated and degraded, and that she be allowed to exist in her unaltered form and in a pristine natural environment.
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> . . . .
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> 21. Geothermal exploration and development will diminish and finally destroy Pele's creative force. This will cause spiritual, cultural, psychological and sociological injury to the people who worship and respect Pele.
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> . . . .
>
> 25. Violation and desecration of the sacred body of the god Pele, as Pele practitioners believe will occur with geothermal exploration and development, will destroy the relationship and communication which Pele practitioners have with the god Pele.

B. Case No. 11334

In this appeal, Appellants challenge the Board's findings with respect to the economic feasibility of the development of geothermal energy. Additionally, they argue the Board has failed to apply its regulations with regard to permitted uses for granting a conservation district use permit in a subzone P (Protected) area.

Both of these contentions are without merit. The Board's findings of fact are presumptively correct, and cannot be set aside on appeal unless they are shown to be "clearly erroneous in view of the reliable, probative and substantial evidence on the whole record." Stop H-3 Ass'n v. State Department of Transportation, 68 Haw. ___, ___, 706 P.2d 446, 451-52 (1985) (quoting HRS § 91-14(g) (1976)). There was more than sufficient evidence before the Board to conclude development of 25 MeW of energy would be presently economically feasible and the island's energy needs would likely increase in the future.

With regard to the subzone classification, the Board redesignated the KMERZ area as a geothermal resource subzone as a result of the previous contested case hearings. Hence, there was no requirement that the Board consider subzone P criteria in granting the conservation district use permit to Campbell.

V.

A claim of constitutional infringement on religious practice requires a burden showing significant harm. Appellants have not shown a burden of constitutional dimension.

Appellants' other assertions of error are also without merit. The April 9, 1985 Decision approving the geothermal resource subzone and the June 18, 1986 Decision granting the conservation district use permit are affirmed.

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BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the matter of the Conservation District Use Application of the ESTATE OF JAMES CAMPBELL	)))))	CDUA NO. HA-12/20/85-1830 DECISION AND ORDER

Decision and Order

Honolulu, Hawaii
April 11, 1986

DECISION AND ORDER

The Board of Land and Natural Resources (BLNR) hereby grants the Estate of James Campbell and the True/Mid-Pacific Venture a Conservation District Use (CDU) permit:

(a) to conduct geothermal exploratory activities to determine the existence of a geothermal resource capable of providing up to 100 megawatts of electrical energy; and

(b) to conduct actual development activities for the purpose of producing up to 25 Megawatts of electrical power within the Kilauea Middle East Rift Geothermal Resource Subzone (KMER/GRS) and for purposes of satisfying the electrical energy requirements for the Island and County of Hawaii. The boundaries of the Kilauea Middle East Rift Geothermal Resource Subzone are delineated on the map attached hereto as Appendix A.

SCOPE

The scope of this permit is defined as follows:

1. "Geothermal exploratory activities" are defined to include those activities which will allow the Applicant or its representatives to determine the nature, location, and extent of the KMER/GRS's geothermal resources and include the drilling of geothermal wells.

(a) Applicant may drill a sufficient number of wells to produce 25 Megawatts of electrical energy. However, exploration activities beyond the firm confirmation of 25 Megawatts for near term development shall be for the purpose of determining generally the existence of a geothermal reservoir capable of providing up to 100 Megawatts of electrical energy.

(b) To this end, the Applicant may drill sufficient additional number of wells beyond those needed to produce 25 Megawatts in order to determine whether another 75 Megawatts of electrical energy could be produced from lands subject to this CDU permit.

2. Upon completion of the exploration phase in this Order and approval of a development plan as provided in paragraph 33 below, the Applicant shall be permitted to develop up to 25 Megawatts of electrical power for purposes of satisfying the electrical energy requirements for the Island of Hawaii.

3. The BLNR approves the development by the Applicant of geothermal energy in excess of the initial 25 Megawatts (but not greater than 100 Megawatts) under this Order only upon the condition that prior to initiating any such further development, the Applicant shall file information with the Board showing that:

(a) it has complied with all of the terms and conditions in this Order;

(b) there is a need for such additional energy production; and

(c) the development of additional geothermal facilities can continue to meet and be in compliance with applicable health and safety requirements of applicable, Federal, State and County statutes.

4. Any development beyond the initial 25 Megawatts may be approved in increments. A development plan addressing the information required in paragraph 33 of this Order shall be submitted by the Applicant to the

DLNR for ministerial approval prior to any further development.

5. Any proposal to explore for or develop geothermal energy in excess of the 100 Megawatts for whatever purpose shall require a new application.

CONDITIONS

The uses permitted by this Order are subject to the following conditions:

Exploration Area

1. Applicant shall submit for approval in accordance with Section 13-183-55 of Chapter 183, Rules of Leasing and Drilling of Geothermal Resources prior to conducting exploration access or drilling activities, a Plan of Operations delineating its specific anticipated activities to implement this Order. The scope of planned exploration activity shall follow or be conducted in a manner consistent with the sequence described in the Final Supplemental Environmental Impact Statement (EIS), pp 14-15.

2. No wells or power plants shall be sited within 3,500 feet of the eastern boundary of the Applicant's property line near Kaohe Homesteads (see Appendix A).

3. No wells or power plants shall be sited within 3,500 feet of the southeastern boundary of the Applicant's property line near Upper Kaimu Homesteads (See Appendix A).

4. Applicant may conduct directional drilling.

Commencement

5. The Plan of Operations shall be submitted within two years of the issuance of the final Order approving the CDU Permit. Exploration activities shall be commenced within two years from the date of approval of the Plan of Operations. Pursuant to Section 13-2-21(C)(1), the Board expressly waives the one year commencement requirement and the three-year requirement for completion of activities due to the complexity of geothermal exploration.

Plan of Operations

6. The Plan of Operations shall also include the following environmental monitoring plans and programs:

a) Venting

Abated venting shall be permitted only when accompanied by appropriate noise and chemical abatement techniques approved by Department of Land and Natural Resources (DLNR). Abated venting, when required and approved, shall be restricted as follows:

(i) venting may occur only between the hours of 9:00 a.m. and 6:00 p.m. exclusive of weekends and State holidays; venting shall not occur for more than a continuous eight-hour period. For good cause shown and when no reasonable alternatives exist, the DLNR may modify these restrictions.

(ii) venting shall be scheduled for periods when meteorological conditions are conducive for minimum impact to adjacent residential areas; and

(iii) forty-eight (48) hours advance notice shall be provided to DLNR, the County of Hawaii, designated representatives of residents in adjacent communities, and the Hawaii Volcanoes National Park as to the scheduled venting.

Unabated open venting of geothermal emissions is prohibited except by prior written permission of the DLNR or in emergency situations.

(b) Management Plan

Applicant shall submit to DLNR for ministerial approval, a management plan relative to access, parking, drainage, fire protection, safety, signs, lighting provisions, and changes in the landscape, for review and approval.

(c) Air Quality Monitoring Program

Applicant shall submit to DLNR for ministerial approval, an Air Quality Monitoring Program to be implemented when the well drilling period begins and shall continue through the term of the project. Such data shall be submitted to the DLNR and the County of Hawaii on a quarterly basis.

The program shall include provisions for installation, calibration, maintenance, and operation of recording instruments to measure air contaminant concentrations. The specific elements to be monitored shall include the following:

(i) hydrogen sulfide and sulfur dioxide;

(ii) mercury;

(iii) radon; and

(iv) other elements and emissions as may be determined by the DLNR.

The number of stations involved in the continuous monitoring program shall include, but not be limited to, at least one (1) station each within Hawaiian Acres Subdivision, Waikahekahe Iki, the Kaohe Homesteads, the Upper Kaimu communities, along the Southern border of the KMER/GRS near area "D" as depicted on Figure 5 of the Final Supplemental EIS and any other locations as required by the DLNR. Rain water sampling shall be done within adjacent and nearby residential communities. Measurements shall be made of total suspended particulates. Said plan and program shall be modified as deemed necessary by the DLNR based on information derived in the initial phase or phases of the project in order to address activities to be undertaken subsequent to such initial phases.

Where appropriate, U.S. EPA monitoring guidelines and protocol will be followed and standard U.S. EPA quality assurance documentation will be provided for the monitoring program. The air quality monitoring program shall be conducted by an independent consultant, selected by the DLNR, but paid for by Applicant.

Applicant shall meet all Federal, State, and County air quality guidelines and regulations. Prior to the adoption of air quality standards by the State Department of Health, the Air Quality Advisory Committee Guidelines shall be binding. In summary, the proposed Department of Health standards are as follows:

(i) maximum ambient: 100 parts per billion;

(ii) ambient - maximum incremental degradation: not more than 25 parts per billion for 1 hour average once/year;

(iii) best available control technology; and

(iv) emissions: 8.5 lbs/hour or 150 grams/gross Megawatt hour, whichever is greater.

Applicant has agreed to and the Board hereby directs that the best available control technology (BACT) shall be utilized for the control of hydrogen sulfide (H_2S) emissions through the term of the project. Applicant has also agreed that hydrogen sulfide emissions during all phases of exploration and development activities shall not exceed regional air quality concentration of 30 parts per billion (1 hour average) above regional background levels at the nearest residential property. In the case of conflicts between standards cited above the most restrictive shall apply. The standards and guidelines in this Order shall apply at the Applicant's property line.

(d) <u>Meteorological Monitoring Program</u>

Applicant shall provide, install, calibrate, maintain, and operate a Meteorological Monitoring Program for continuous meteorological monitoring at the subzone or at other locations as may be required by the DLNR. The data shall be provided in a format that is acceptable to the DLNR, and made available to DLNR and the County of Hawaii on a monthly basis and shall include temperature, wind velocity, wind direction, precipitation, vertical air temperature, and other information deemed necessary by the DLNR.

(e) Noise Monitoring Program

A Noise Monitoring Program to be implemented prior to the exploratory well drilling and testing period begins shall be submitted to DLNR for ministerial approval. Said plan and program shall be submitted to the County of Hawaii and other appropriate government agencies for review and comment prior to its approval.

The Noise Monitoring Program shall include an evaluation of predicted noise levels for selected sites in the residential areas near the proposed drilling and testing operations in the KMER/GRS. The evaluation shall include, but is not limited to, the collection of meteorological data simultaneously with ambient sound level monitoring. The program shall simulate actual sound levels at each of the proposed well sites and measure noise levels at selected residential areas using calibrated noise sources. The noise evaluation shall be submitted to DLNR for ministerial approval prior to approval of permission to drill at each site. This plan should be designed so that any complaints about noise can be correlated with noise measurements, the meteorological conditions, and the type of operations which occurred at a well site at a particular time and day. The number and location of on-site and off-site monitoring stations shall be subject to the determination of DLNR. Mobile stations may be used.

The noise level monitoring and standards shall be applied at receptors located in at least one (1) station each within Hawaiian Acres

Subdivision, Waikahekahe Iki, the Kaohe Homesteads, the Upper Kaimu communities, along the Southern border of the KMER/GRS near area "D" as depicted on Figure 5 of the Final Supplemental EIS and any other locations as required by the DLNR.

The data obtained shall be available on request by the appropriate governmental agencies, including the County of Hawaii. The noise monitoring program shall be in operation during the term of the project.

Until such time as noise regulations are adopted by the State or County, the Applicant or its representative shall comply with the following guidelines:

(i) a general noise level of 55 dba during daytime and 45 dba at night shall not be exceeded at the Applicant's property line except as allowed under (ii). For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

(ii) the allowable noise levels may be exceeded by a maximum of 10 dba for impact noise; but in no event, may this impact noise constitute more than 10 percent of the time within any 20-minute period;

(iii) the noise level guidelines shall be applied at the Applicant's property line; and

(iv) sound level measurements shall be conducted using standard procedures with sound level meters using the "A" weighting and "slow" meter response, unless otherwise stated.

The above guidelines shall be enforced and may be administratively adjusted by the DLNR based on information derived in the initial phase or phases of the project in order to address activities to be undertaken subsequent to such initial phases.

(f) Archaeological Plan

An Archaeological reconnaisance survey for clearing operations on specific sites for project facilities including roads, drilling and power plant sites shall be submitted to DLNR for ministerial approval. Based upon the survey, the Applicant shall submit a plan to address methods to avoid archaeological sites that are determined worthy of preservation or removal. More specifically:

(i) a full archaeological reconnaisance survey shall be conducted for any area selected to be cleared for any project operation, prior to the initiation of clearing operations. The survey shall identify and evaluate sites and features of potential archaeological significance present within the areas to be cleared. It shall be conducted in accordance with the standards for reconnaisance level survey recommended by the Society for Hawaiian Archaeology (SHA).

(ii) the areas to be surveyed shall include the proposed access corridors, drill sites, power plant sites and any other areas to be impacted by construction activities. These areas will be clearly marked on-the-ground prior to any archaeological field work.

(iii) the area to be surveyed shall include an area two to five times larger than the actual access road corridors, drill sites, power plant sites, and any other development areas -- to insure that any archaeological resources in the immediate vicinity, but not actually within a specific area to be impacted will not be inadvertently damaged by construction activities. The surveyed area should insure that the full context of archaeological remains within the specific impact areas will be determined (e.g., the full significance of a seemingly isolated structure cannot be accurately determined if it is part of a larger, but unidentified, complex of structures).

(iv) an archaeological research design to guide all future archaeological work within the project area will be formulated. A research design will be a plan for conducting an archaeological investigation.

(g) <u>Clearing</u>

Prior to the commencement of any grubbing, grading or clearing activities, the Applicant or its representative shall:

(i) provide a metes and bounds description of proposed well sites, the power plant sites, and access roads to the DLNR for approval;

(ii) mark the boundaries of the well sites, power plant sites, and access roads such that no construction or transportation equipment shall be permitted beyond such boundaries;

(iii) receive approval on archaeological and biological reconnaissance surveys for specific sites or facilities; and,

(iv) comply with all requirements of Chapter 10, Erosion and Sedimentation Control, Hawaii County Code, as amended.

(h) <u>Biological Survey</u>

The Applicant or its representative shall submit to DLNR for ministerial approval, a biological survey, monitoring and assessment program. The program shall address the following:

(i) biological reconnaissance surveys to be conducted for those areas to be impacted by exploration and development activities, including those areas altered by any clearing for drill sites, future power plant sites, access roads and utility or transmission corridors. Such surveys shall be conducted in conjunction with preliminary land surveying activities and shall be submitted to the DLNR for review and approval and to the County of Hawaii and other appropriate government agencies for review and comment prior to approval of commencement of construction activity.

(ii) Applicant shall establish baseline biological data for the contiguous area two to five times larger than the area to be cleared.

(iii) monitor the spread of exotic plants into the project area along roads and clearings and the implementation of appropriate control methods approved by the DLNR.

Suitable areas within the subject property shall be identified and designated, by mutual agreement of the Applicant and the DLNR, as botanical sanctuaries.

(i) Lighting

Lights on the drilling rig and physical components and lights required during operations at the drilling site shall be shielded and of the lowest intensity as is consistent with worker safety, security, and efficient operations. In any event, all activities and facilities shall meet the requirements of Chapter 14, Article 9, Outdoor Lighting, of the Hawaii County Code, as amended.

(j) Drilling Report

Applicant shall submit a status report to DLNR and the County of Hawaii on a semiannual basis, or within 30 days whichever occurs first, of the completion of any exploratory well. The status report shall include, but is not limited to:

(i) a detailed description of the work undertaken during the current reporting period, including well test data, exploration results and drilling logs;

(ii) well history report, well summary report and a supplementary notice;

(iii) a log of the complaints received and the responses;

(iv) a description of the work being proposed over the next reporting period; and

(v) any other information that DLNR may require which will address environmental and regulatory concerns involving the requirements of the CDU permit.

(k) Emergency Plan

Applicant shall submit and obtain approval from the Hawaii County Civil Defense Agency and the DLNR of a plan of action to deal with emergency situations such as volcanic activities, earthquake, fires and well bore ruptures, and blowouts which may threaten the health, safety, and welfare of the employees and other persons in the vicinity of the proposed project. The plan shall include procedures to facilitate coordination with appropriate State and County officials and the evacuation of affected individuals.

Reforestation

7. All denuded areas on and around completed or abandoned drilling sites shall be reforested in a manner acceptable and approved by the DLNR. In the case of total abandonment of the project, Applicant shall restore all denuded areas, including the access road and secondary field roads in a manner acceptable and approved by the DLNR.

Water

8. The Applicant or its developer shall conduct water analyses before and periodically during drilling of the first well in each development area. Samples and analysis of catchment water in Kaohe Homesteads and Upper Kaimu Homesteads shall be conducted by a licensed water quality testing laboratory and results provided to the State Department of Health and the County of Hawaii as well as DLNR within 15 days after samples are analyzed.

Disposal

9. A disposal site or sites, approved by the DLNR and State Department of Health, shall be provided for sump contents and other waste materials to be disposed of from the drilling activity.

Debris

10. On-site burning of debris material is prohibited unless expressly authorized in writing by the DLNR and all applicable State and County agencies.

Ponds

11. All sump/ponds shall be purged in a manner meeting with the approval of the DLNR and State Department of Health.

Aesthetics

12. In the design and construction of all physical components, Applicant shall propose measures to minimize aesthetic and scenic impact and to preserve the natural beauty of the area. Such measures shall, but is not limited to, orientation of buildings, when feasible, with the narrow dimension towards any view corridor from which large numbers of the public would be able to observe the facility, paint to blend with the background for the facility, and the use of nonreflective, light absorbent material and textures. Applicant shall be subject to the County building code. Prior to commencement of any construction or

improvements, the Applicant shall submit four (4) copies of each of the final locations, maps, plans, and specifications to the Chairperson for approval pursuant to DLNR rule 13-2-21(a)(7).

Road Fill

13. All cut and fill materials for road construction shall be derived from the project site. No imported materials shall be allowed unless prior written approval by the DLNR is obtained.

Clearing Approval

14. All clearing for construction proposes shall require prior ministerial approval by the DLNR. Ground cover of slopes over 40% shall not be removed unless specifically authorized by the DLNR.

Traffic

15. Heavy truck traffic into the project site shall be restricted to daylight hours except for emergencies and unusual operational conditions. All access roads shall be maintained in good condition by the Applicant including roads over other private property.

Litter

16. All litter shall be collected and disposed of daily.

Blasting

17. No blasting operations shall be allowed without the prior written

approval of the DLNR.

Production Report

18. Applicant shall submit to the DLNR on or before the last working day of the month a report on the amount of geothermal resources produced, sold, and used, and the amount of fluid injected for that month as the case may be.

Operation Record

19. Applicant or its representative shall maintain a record in a permanent form which is suitable for inspection and shall make such record available on request to the DLNR, the State Department of Health, and the County of Hawaii and any such authorized Federal, State, or County officials as they may designate. The record shall include, but is not limited to:

(a) occurrence and duration of any start-up, shut-down, and operation mode of any well/facility;

(b) performance testing, evaluation, calibration checks,and adjustments and maintenance of the continuous emission monitors that have been installed; and

(c) emission measurements reported in units compatible with applicable standards and guidelines.

Inspection

20. Applicant shall grant unrestricted access, subject to safety measures normal and necessary during operations, to authorized governmental

representatives, including the County of Hawaii, or to consultant and contractors hired by governmental agencies for inspection, enforcement, or monitoring activities.

Information and Complaints

21. (a) Applicant shall designate an individual and an alternate who are to be readily available at all times and who has authority to act on behalf of the Applicant for the purposes of supplying information and responses deemed necessary by the authorized governmental representative who is involved with such activities.

(b) Applicant shall publish a telephone number staffed 24 hours a day for receiving noise, odor, or other complaints and shall have an employee available at the project site, 24 hours a day, to respond to such complaints. Applicant shall keep a log of all complaints received and their responses to be submitted to the DLNR quarterly.

Indemnification

22. (a) Applicant, its successors or assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the Applicant, its successors, assigns, officers, employees, contractors, and agents under this Order and permit or relating or connected with the granting of this permit.

(b) Applicant shall protect, indemnify, defend and hold the State of Hawaii harmless against loss, damages, claims and liens of every kind and character (including but not limited to Workmen's Compensation claims and claims of third parties) which may be occasioned by Applicant's use or occupation of the Land or any portion thereof or any easement for ingress or egress thereto or by reason of the operations or working of Applicant, its employees, agents or independent contractors upon the Land, or any easement for ingress or egress thereto, including injuries to persons or loss of life or damage to property or nuisance and including, but not limited to, any pollution or flooding of the surface or subsurface waters or any pollution of the air, with said indemnification to apply irrespective of whether claims allege the cause to be sudden or gradual.

Insurance

23. Furthermore, Applicant will at its own expense effect and maintain at all times term insurance coverage for automobile liability, professional liability and comprehensive general liability for all risks with respect to the subject land under policies naming the State of Hawaii as an additional insured by an insurance company authorized to do business in Hawaii, such insurance being for injury to one or more persons in any one accident or occurrence and for property damage, respectively, with minimum limits of $5 million or such higher limits as is consistent with prudent business practice prevailing from time to time and with the risks involved in the geothermal industry, and will from time to time deposit with the DLNR current certificates of such insurance and upon request therefor true copies of such insurance policies. Such insurance policies that are to be provided by Applicant shall contain a clause stating such

policies are primary and non-contributing with any other insurance that may be in force on behalf of the State of Hawaii, which shall not be construed to prevent Applicant from carrying excess coverage.

Pollution

24. Pollution of the ocean and tidelands, rivers, or other bodies of water, and all impairment of and interference with bathing, fishing, or navigation in the waters of the ocean or any bay or inlet thereof is prohibited, and no brine, minerals, or any refuse of any kind from any well or works shall be permitted to be deposited on or pass into waters of the ocean, any bay or inlet thereof, rivers, lakes, or other bodies of water, without specific written State authorization.

Health Hazard

25. No substances which may be produced from any well drilled upon the lands shall be blown, flowed, or allowed to escape into the open air or on the ground in such a manner as to create a health hazard, which shall specifically include but not be limited to noise, air or other pollution, and other activities which disturb the occupier's or his tenant's use of the lands. Subject to the foregoing, the Applicant may bleed substances into the atmosphere so long as such operations are lawfully and prudently conducted in accordance with good geothermal drilling and exploratory testing practices and are not otherwise in violation of the law.

Compliance with land laws

26. The Applicant shall comply with all valid requirements of all municipal, state, and federal laws and regulations pertaining to the lands and Applicant's operations, which are now in force or which may hereafter be in force, including, but not limited to, all water and air pollution control laws, and those relating to the environment. The State of Hawaii, acting in its governmental capacity, may regulate the drilling, location, spacing, testing, completion, production, operation, maintenance, and abandonment of a well or wells or similar activity as well as the construction, operation, and maintenance of any other facilities in the exercise of its police powers to protect the public health, welfare, and safety as provided in the regulations.

Fines

27. Any violation of any particular condition and each occurrence thereof shall be subject to a fine as provided by law. The DLNR shall have authority at all times to close, shut down, terminate, modify, or otherwise impose limitations on any well or any geothermal activity for violations which may endanger public health or safety. The Applicant and its agents, assigns, and successors in interest shall be liable for each and every administrative cost incurred by any and all State and County agencies or personnel which may be required for the investigation and enforcement of violations.

Monitoring Costs

28. All monitoring program costs shall be borne by Applicant. The

Department shall reserve the right to approve consultants for such programs.

Compliance with laws

29. Applicant shall comply with all Federal, State and County laws, statutes, regulations and ordinances listed in Appendix "B" that may apply.

Continuing jurisdictions

30. The Board shall exercise continuing jurisdiction over all exploratory and development activities authorized by this Order.

Best Available Control Technology

31. Applicant shall at all times apply the "Best Available Control Technology" (BACT) with respect to geothermal emissions and noise abatements during all phases of the project, including well drilling, testing, and power plant operation. "Best Available Control Technology" means the maximum degree of control for noise and air quality concerns, taking into account what is known to be practical but not necessarily in use. BACT shall be determined by DLNR in consultation with appropriate State, County, and Federal agencies involved in the control or regulation of geothermal development.

Soil and Water Conservation

31. Use of the area shall conform with the program of the appropriate

soil and water conservation district or plan approved by and on file with the DLNR.

Sanitation

32. When provided or required, potable water supply and sanitation facilities shall have the approval of the DLNR, State Department of Health and the County of Hawaii.

Development Plan

33. (a) Prior to any development, the Applicant or its representative shall submit a complete development plan describing all proposed surface and structural improvements for the proposed activities to the DLNR for review and approval and the County of Hawaii and other appropriate government agencies for review and comments prior to its approval by the DLNR.

(b) A development plan shall include, but not limited to:

- o well and power plant site locations
- o additional access corridors
- o pipeline corridors
- o electrical transmission line corridors
- o conceptual construction plans
- o description of abatement systems

Commencement of Development

34. Development of an electrical generation facility shall commence within five years after completing a successful exploration phase of up to 25 Megawatts.

Dated: Honolulu, Hawaii, April 11, 1986.

IT IS SO ORDERED.

SUSUMU ONO
Chairperson and Member,
Board of Land and Natural
Resources

J. DOUGLAS ING

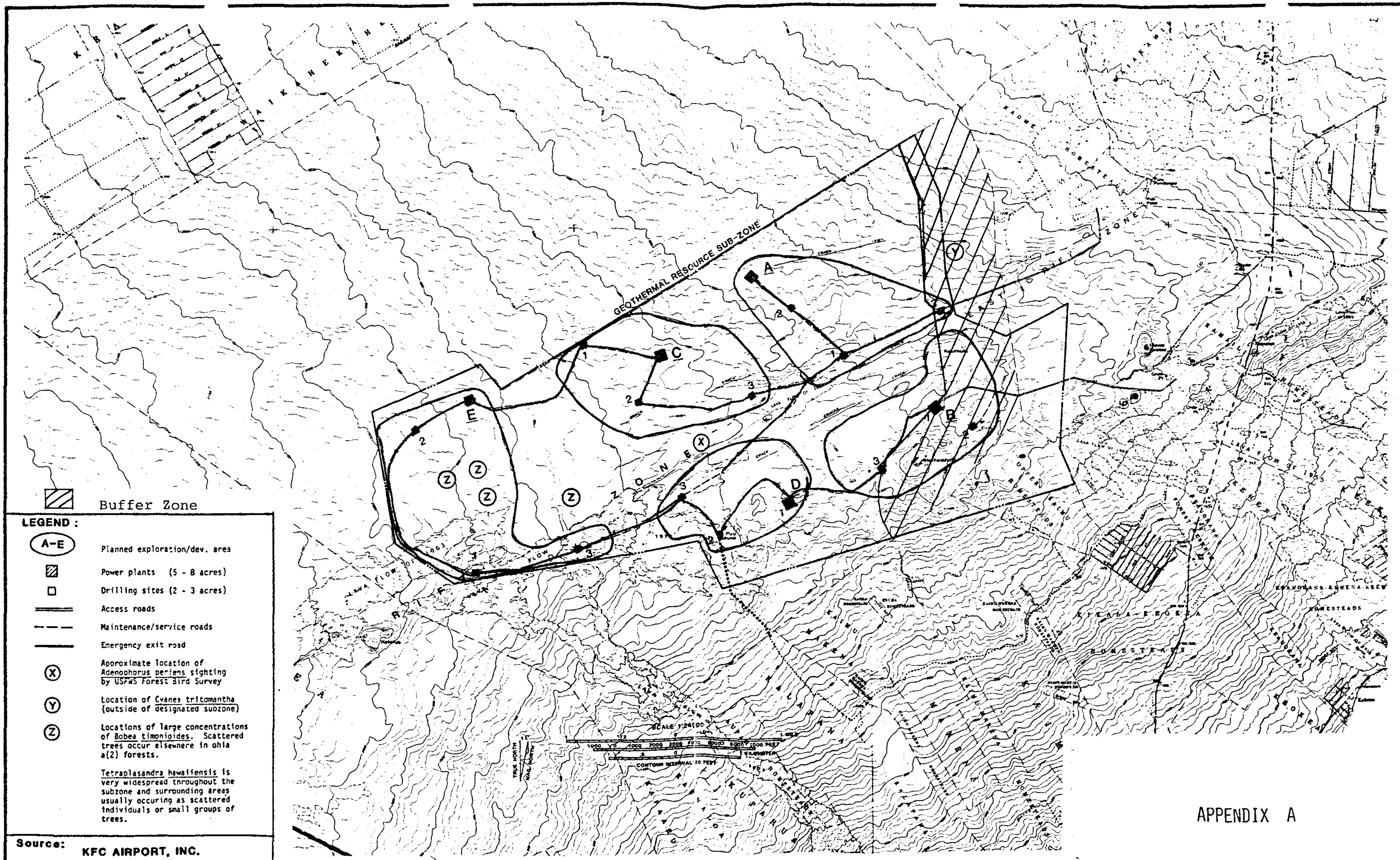
Board Member

ROLAND H. HIGASHI

Board Member

MOSES KEALOHA

Board Member


GEOTHERMAL RESOURCE SUB-ZONE
Buffer Zone
LEGEND :
A–E
Planned exploration/dev. area
Power plants (5 - 8 acres)
Drilling sites (2 - 3 acres)
Access roads
Maintenance/service roads
Emergency exit road
Approximate location of Adenophorus periens sighting by USFWS Forest Bird Survey
Location of Cyanea tritomantha (outside of designated subzone)
Locations of large concentrations of Bobea timonioides. Scattered trees occur elsewhere in ohia a(2) forests.
Tetraplasandra hawaiiensis is very widespread throughout the subzone and surrounding areas usually occuring as scattered individuals or small groups of trees.
Source: KFC AIRPORT, INC.

APPENDIX A

APPENDIX "B"

TABLE OF FEDERAL AND STATE LAWS

I. FEDERAL LAWS

A. Statutes

1. Toxic Substance Control Act, 15 USC 2061, et. seq.

2. National Parks Organic Act, 16 USC 1, et. seq.

3. Enabling Act Volcanoes National Park, 16 USC 391, et. seq.

4. Fish and Wildlife Coordination Act, 16 USC 661, et. seq.

5. Wilderness Act, 16 USC 1131, et. seq.

6. Marine Protection, Research and Sanctuaries Act, 16 USC 1431, et. seq.

7. Endangered Species Act, 16 USC 1531, et. seq.

8. Public Utilities Regulatory Policy Act, 16 USC 2061, et. seq.

9. Geothermal Steam Act, 30 USC 1001, et. seq.

10. Geothermal Energy Research and Development Act, 30 USC 1101, et. seq.

11. Federal Water Pollution Control Act, 33 USC 1251, et. seq.

12. Safe Drinking Water Act, 42 USC 300 f., et. seq.

13. National Environmental Policy Act, 42 USC 4321, et. seq.

14. Noise Control Act, 42 USC 4901, et. seq.

15. Federal Non-nuclear Energy Research and Development Act, 42 USC 5901, et. seq.

16. Resources and Conservation and Recovery Act, 42 USC 6901, et. seq.

17. Clean Air Act, 42 USC 7401, et. seq.

18. Historic Preservation Act

19. Coastal Zone Management Act

20. Flood Plain Management Act

21. Rivers and Harbors Act

22. Geothermal Loan Guarantee Act

23. National Energy Act

24. Geothermal Energy Act of 1980

B. Federal Regulations (CFR)

1. Prevention of Significant Deterioration Regulations, 40 CFR 52.21.

II. STATE LAWS

A. Hawaii Revised Statutes (H.R.S.)

1. Ground-water Use, HRS Chapter 177-19

2. Wells, HRS Chapter 178-5

3. Soil And Water Conservation Districts, HRS Chapter 180

4. Government Mineral Rights, HRS Chapter 182

   a. HRS Chapter 182-2

   b. HRS Chapter 182-6

5. Forest and Water Reserve Zones, HRS Chapter 183-41

6. Natural Area Reserves System, HRS Chapter 195

7. Conservation of Wildlife and Plants, HRS Chapter 195D

8. Energy Resources, HRS Chapter 196

9. Land Use Commission, HRS Chapter 205

   a. HRS Chapter 205-2

   b. HRS Chapter 205-5

10. Coastal Zone Management Act, HRS Chapter 205A

11. Hawaii State Planning Act, HRS Chapter 226

12. Public Utilities Commission: Establishment geothermal energy rates, HRS Chapter 269-27.1, and 27.2

13. Safe Drinking Water, HRS Chapter 340E-2

14. Environmental Quality Commission and Environmental Impact Statements, HRS Chapter 343

    a. HRS Chapter 343-5 (a)(2)(A)

    b. HRS Chpater 343-5 (c)

B. Administration Rules, Board of Land and Natural Resources

1. Conservation Districts, Title 13, Chapter 2

    a. Section 13-2-1, Chapter 2

    b. Section 13-2-21, Chapter 2

2. Rules of Practice and Procedure, Title 13, Chapter 1

3. Rules on Leasing and Drilling of Geothermal Resources, Title 13, Chapter 183

III. COUNTY

Chapter 15, Hawaii County Ordinance.

CERTIFICATE OF SERVICE

It is hereby certified that a copy of Decision and Order on the Conservation District Use Application No. HA-12/20/85-1830 for the exploration and development of Geothermal Energy at the Kilauea Middle East Rift Geothermal Resource Subzone was duly served upon the following persons at their last known addresses by either hand delivery or by depositing same in the United States mail, postage prepaid, on April 11, 1986.

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ATTORNEYS FOR VOLCANO COMMUNITY
ASSOCIATION, ET. AL.

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone	GS No. 9/26/85-5 PROPOSED FINDINGS OF FACT OF VOLCANO COMMUNITY ASSOCIATION, ET. AL.

PROPOSED FINDINGS OF FACT OF
VOLCANO COMMUNITY ASSOCIATION, ET. AL.

Comes now VOLCANO COMMUNITY ASSOCIATION, ET. AL., by and through its attorneys, KENNETH KUPCHAK and WENDELL ING, and hereby presents its Proposed Findings Of Fact.

TABLE OF CONTENTS:

A. CURRENT BIG ISLAND NEED FOR GEOTHERMAL

1. That the current need for additional base-load energy on the Big Island by the year 1991 is about 13 megawatts, all or part of which could be from geothermal. See Testimony of Alva Nakamura, Tr., Vol. IV, p. 104, 110]

2. Actual need of HELCO for additional base-load energy by the year 1991 is closer to 8.5 megawatts, but 13 megawatts is the smallest amount that is economically feasible. See oral testimony of Alva Nakamura, Tr., Vol. IV, p. 119]

3. There are no planned retirement schedules for any of HELCO's oil fired plants. [See oral testimony of Alva Nakamura, Tr., Vol. IV, p. 111]

4. Federal PURPA laws require that HELCO purchase power from all alternate energy sources, such as wind or biomass, unless such purchase causes problems within their operational grid. [See oral testimony of Alva Nakamura, Tr., Vol. IV, p. 119]

5. The energy needs of the Big Island could be fulfilled through the combination of biomass, hydroelectric power, and wind power, without any geothermal power. [See oral testimony of Alva Nakamura, Tr., vol. IV, p. 132-33]

6. That lower Puna reservoirs within the Kamaili and Kapoho subzones appear to have the potential to produce 150 to 500 megawatt centuries or more of geothermal power. [See Furumoto oral testimony on 12/16/84, and Furumoto written testimony, VCA Ex. 12, 51 & 52 at Kahauale'a geothermal subzone hearing, GS 8/27/84-1]

B. SCOPE OF SUBZONE ASSESSMENT PROCESS

7. DOWALD did not establish any particular megawatt scenario of Big Island needs for its subzone assessment process, other than establishing a 25 megawatt scenario for the social and economic impact studies. [See oral testimony of Manabu Tagamori, Tr., Vol. I, p. 77]

8. Bay Yee would consider there to be much larger effects or impacts from more full scale geothermal development such as 250 megawatts. [See oral testimony of Bay Yee, Tr., Vol. I, p. 123-4].

9. DOWALD did not assess or consider potential impact of geothermal upon invertebrates. The Puna Biotic Assessment by Dr. Charles Lamoureux did not investigate impact on invertebrates. [See oral testimony of Dr. Lamoureux, Tr., Vol. VI, p. 107; also oral testimony of Mae Mull, Tr., Vol. V, pp. 77-83]

10. DOWALD did not mention any assessment or consideration of potential impact of geothermal upon either the unique "successional mosiac", the lava tube ecosystem or the Neogeoaeolian ecosystem in the MER, although DOWALD was previously aware of the existence of those from a February 12, 1985 meeting between Dean Nakano, Sherrie Samuels, and Joe Kubacki of DOWALD, Frederick Warshauer, and Jim Brock:

> "On February 12, 1985. . . data was presented relating to the assessment of the Kilauea Middle East Rift Zone as a potential geothermal resource subzone. . . Mr. Warshauer presented information to the group concerning existing types of vegetation contained within the Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve. . . The following data and concerns were expressed by Mr. Warshauer:

> Most vegetation north of the Kilauea Middle East rift is over 250 years old and is uniform in age and growth.
>
> Vegetation south of and along the rift zone is highly variable, young in age, and exhibits evolution or succession of growth.
>
> Successionary type vegetation . . . [and] the Neo-Geo-Eolian and lava tube ecosystems, are more importatnt than native closed canopy forests.
>
> Although pristine native forests, such as those found in Kahauale'a, are important habitats for the Adenophorus periens fern and the O'u bird, it is of equal or greater value to preserve areas exhibiting early stages of vegetative growth to study the natural chain of succession of native and exotic plants.
>
> The . . . ["successional mosaic"] ecosystem is limited to the southern portion of the Kilauea Middle East Rift Zone, in that, vegetation composition varies with elevation and climate (i.e. wet vs. moist environment).
>
> Open canopy or shrublands that are native dominated are equally important as Category 1, closed canopy, exceptional native forest.
>
> Only a portion of the NARS area should be exchanged for Kahauale'a lands. The area south of the rift axis within the 90% probability line should be retained and protected by keeping the area designated as NARS. The area north of the rift axis including the Puna Forest Reserve should be fully considered as part of the exchange."
>
> [See State Exhibit 7, Memo from Dean Nakano, 2/12/85]

11. That in-depth surveys of the MER should have been done to make extensive collections of the insect fauna, prior to any subzone designation process. No such survey has been done in the MER area to date, due to lack of resources. [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, pp. 32-33]

C. SOCIAL IMPACT

12. Mr. Tagamori admitted DOWALD did not utilize anyone with a formal sociological background or sociological training in assessing the potential social impacts. [Tr., Vol. 4, pg. 19]

13. Mr. Bay Yee, who was primarily responsible for the social impact assessment of all the subzones, admitted that they did not utilize anyone with formal sociological background or training in assessing the potential social impacts of the various subzones: Question: "Mr. Yee, was there anyone who was a trained sociologist working on the social impacts study." Answer: "No." [See oral testimony of Bay Yee, Tr., Vol. I, p. 132]

14. A scenario of only up to 25 megawatts was considered by DOWALD in assessing social impacts for the subzone designation process. See oral testimony of Manabu Tagomori, Tr., Vol. IV, p. 46]

15. Mr. Chuck of DOWALD told Bay Yee to only consider a scenario of 20 to 30 megawatts for assessing social impacts for the subzone designation process. [See oral testimony of Bay Yee, Tr. , Vol. I, p. 124]

16. Bay Yee would consider there to be much larger effects or impacts from more full scale geothermal development such as 250 megawatts. [See oral testimony of Bay Yee, Tr., Vol. I, p. 123-4].

17. No literature was reviewed regarding potential impacts of large scale geothermal development such as 250 to 500 megawatts. [See oral testimony of Bay Yee, Tr., Vol. I, p. 124]

D. SIZE AND CONFIGURATION OF SUBZONE

18. That according to an analysis and proposal by Thermal Power in February 1981, a previous potential developer of the Kilauea Middle East Rift area ["MER"], only 6500 acres were needed for geothermal exploration in the MER. [See Letter, Thermal Power Co. to Susumu Ono, STATE Ex. 6]

19. That according to that analysis and proposal by Thermal Power in February 1981, only 80% of the foregoing 6500 acres, or 5200 acres, were probably needed for geothermal development. [See Letter, Thermal Power Co. to Susumu Ono, STATE Ex. 6]

20. Therefore, conversely, the area proabably needed for exploration according to Thermal Power Co.'s estimate was 125% of the area needed of development [6500 acres for exploration divided by 5200 acres for development equals 1.25]

21. That only 1727 acres are probably needed for development of about 150 megawatts in the MER [11.5 acres per megawatt] according to reservoir engineer Gerald Niimi. [See oral testimony of Gerald Niimi, Tr., Vol. VI, p. 95]

22. That only 1250 acres are probably needed to develop 110 megawatts in the MER [11.4 acres per megawatt]. [See oral testimony of Gerald Niimi, Tr., Vol. VI, pp. 89a-90; p. 94-95].

23. Based on Thermal Power's estimate of 125% of the development area is probably needed for the exploration phase, then, referring to the acreages which Campbell's witness Niimi said were necessary for development in the MER (See Findings #20 & 21 above) 2156 acres would be needed for exploration for 150 megawatts; 1581 acres would be needed for exploration for 110 megawatts. Other extrapolations of acreage needed for various

scenarios are set forth in the table below:

Scale	Development Area Needed	Exploration Area Needed
13 Mw	150 acres	187 acres
25 Mw	288 acres	360 acres
110 Mw	1265 acres	1581 acres
150 Mw	1725 acres	2156 acres
250 Mw	2875 acres	3594 acres

24. That reservoir engineer Niimi considered that 30% of the proposed MER subzone could be "left alone" because those areas contained some particular biological value, and he indicated those areas included the southwest corner, the southeast corner, areas up at the the northwest, and the area around Heiheiahulu. See oral testimony of Niimi, Tr., Vol. VI, pp. 90-91]

25. That a northwestern portion of the proposed Middle East Rift subzone contains a portion of essential habitat for the endangered native bird, the O'u. [See Testimony of Dr. Sheila Conant, VCA Ex. 10, p. 2; Tr., Vol. II, p. 45]

26. That a southwest portion of the proposed Middle East Rift Subzone, the "mosaic community", is inappropriate for geothermal development at this time, as described by Dr. Ken Kaneshiro in VCA Exhibit 21]

27. That a southwest portion of the proposed Middle East Rift Subzone, the "mosaic community", is a sensitive area that should be avoided, as described by James Jacobi. [See Tr., Vol. IV, pp. 242-43 and Warshauer Exhibit 2]

28. For preserve design, large contiguous blocks are far better than equal areas make up of smaller segments because of considerations for minimizing "edge effect", dispersal needs of succession, and reducing the dispersal of exotics from outside.

[See oral test. of Warshauer, Tr., Vol. VI, pp. 76-77]

E. BIRDS

29. There are populations of birds in the proposed MER subzone or the Natural Area Reserve that may have developed genetic resistance to diseases associated with mosquitoes, because those bird populations are living right alongside the mosquitoes. Such bird populations are worth protecting to assist in spreading the genetic potential for resistence to these diseases to other parts of the bird population. [See oral testimony of Dr. Sheila Conant, Tr., Vol. II, pp. 45-46]

30. Dr. Sheila Conant believes that although the O'u is rare, that this bird has a chance of surviving, if it and its habitat area are protected. [See oral testimony of Dr. Sheila Conant, Tr., Vol. II, pp. 49-50]

31. Bird populations need large areas of habitat to be protected, because they are mobile and get their resources from a larger area. If you break up habitats into small pieces, species tend to be lost or to become locally extinct. [See oral testimony of Dr. Sheila Conant, Tr., Vol. II, p. 46]

F. BIOLOGY

32. That the southwestern portion of the proposed Middle East Rift subzone contains a "mosaic" of different forest types which is exceptionally valuable for scientific research, including but not limited to evolutionary biology and genetic research. [See oral testimony of Dr. Ken Kaneshiro, Tr. , Vol. II, pp. 11-12, 15, 19, 22-24, 34-35; also Biological Summary in Puna by James Jacobi, VCA Ex. 7, p. 17]

33. This "mosaic area" should be maintained in a Natural Area Reserve status, and in a "P" subzone, conservation district status. [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, pp. 22-23]

34. That the mosaic area of the Kilauea East Rift Zone is a special ecosystem unique to that geographic area. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, pp. 1-2; see also oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, p. 24; also Biological Summary in Puna by James Jacobi, VCA Ex. 7, p. 17]

35. The Natural Area Reserve Commission requested that as much as possible of the rift zone portion of the Wao Kele O Puna Natural Area Reserve be retained as a natural area reserve status. [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, p. 23

36. That Mr. Tagamori of DOWALD admitted that DOWALD'S consideration of geothermal impacts did not include an analysis of the "explosive speciation" in the southwestern portion of the proposed MER as discussed by Dr. Ken Kaneshiro. [See Tr.,

37. The "mosaic area" of the Kilauea Rift Zone is unique and very special because of the kind of "explosive speciation" in the area. [Oral Testimony of Dr. Ken Kaneshiro, Tr., Vol. 2, p. 20].

38. One would expect to find more opportunities for finding organisms having potential economic and medical use, as a result of concentrated genetic variety and change in the "mosaic area". [Oral Testimony of Dr. Ken Kaneshiro, Tr., Vol. 2, p. 20]

39. That due to lack of resources, the mosaic area has yet to be explored for useful genetic material, and if that portion of the MER were retained as a Natural Area Reserve, this area would be available for genetic exploration when funds become available. [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, pp. 32-33]

40. Regarding genetic research, there is a high probability of finding some unique drosophila species in the "mosaic" area of Wao Kele 'O Puna. [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, p. 34]

41. That the northeastern portion of the proposed Middle East rift subzone is adjacent to residential and agricultural zoned lands. See oral testimony of Kirkendalls, Siracusa, Avery and Perreira, Tr., Vol. V, p. 85-117]

42. Along and south of the East Rift Zone of windward Kilauea lies a unique assemblage of wet and moist forest types that has a biological richness and dynamism far greater than the more uniform forests on geologically older substrates surrounding it. This assemblage is found only on a portion of these wetter windward slopes of Kilauea. [See Testimony of Frederick Warshauer, p. 1]

43. The surface of Kilauea is geologically very young and varied due to frequent eruptive activity. This geology of Kilauea plus the abundant rainfall on the East Rift of Kilauea have fostered the development of a "mosaic" landscape composed of patches (kipuka) of differentially developed vegetation. This is a unique ecosystem. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, pp. 1-3; also written testimony of

James Jacobi, VCA Ex. 5, p. 2 and VCA Ex. 7, p. 17]

44. The unique dynamics of this "mosaic" area in the Middle East Rift Zone lead to conditions of high biological diversity, high genetic diversity, rapidly developing vegetation and frequent isolating of plant and arthropod communities, which causes "explosive speciation". [See oral testimony of Dr. Ken Kaneshiro, Tr., Vol. II, pp. 11-12, 15, 19-20, 22-24, 34-35]; also Biological Summary in Puna by James Jacobi, VCA Ex. 7, p. 17; also written testimony of Frederick Warshauer, Warshauer Ex. 1, pp. 1-2]

45. The "mosaic" region is particularly susceptible to man-induced disturbances that may occur from geothermal exploration and development; the greater the area and scope of geothermal exploration and development, the greater the impacts on the biota will be. [See written testimony of James Jacobi, VCA Ex. 5, p. 2; also written testimony of Frederick Warshauer, Warshauer Ex. 1, p. 5, 7-8]

46. DOWALD did not assess or consider potential impact of geothermal upon invertebrates. The Puna Biotic Assessment by Dr. Charles Lamoureux did not investigate impact on invertebrates. [See oral testimony of Dr. Lamoureux, Tr., Vol. VI, p. 107; also oral testimony of Mae Mull, Tr., Vol. V, pp. 77-83]

47. Dr. Kaneshiro stated that there are undiscovered species of insects in the "mosaic" area within the proposed MER subzone. [See oral testimony of Dr. Kaneshiro, Tr., Vol. II, pp. 12, 15, 19-20, 45]

48. Two additional ecosystems are found in the Kilauea

Middle East Rift Zone, both of which are dominated by arthropods, rather than by photosynthesizing plants, and which are dependent upon the adjacent plant-dominated ecosystem for its energy source. These are the lava tube ecosystem and the neogeoaeolian ecosystems. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, pp. 4-5; Memo from Dean Nakano of DOWALD dated 2/1/85, State Ex. 7]

49. The subterranean lava tube ecosystem exists within the surface or near surface pahoehoe flows that have developed an ohia forest upon them. Highly specialized insects and spiders live in the dark and damp lava tubes and associated cracks, living off ohia roots and other insects cohabiting the dark zone. This ecosystem can exist only as long as contact with living ohia roots is maintained and the tubes and fissures remain open, cool, dark and damp. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, pp. 4-5]

50. The other ecosystem, the Neogeoaeolian ecosystem, occurs on recent, barren or very sparsely vegetated lava flow surfaces, and depends upon an aerial drift of arthropods from adjoining vegetated flows and kipuka to provide the energy source. In addition to eating each other, the crickets and spiders which dominate the system scavenge upon waif arthropods that drift or fly across the flow and are killed or marooned by the harsh surface conditions. This ecosystem is transitory and is dependent upon a periodic renewal of fresh lava surfaces to colonize, as natural forest succession ameliorates the harsh surface conditions and thus diminishes the scavengeable waif food supply (energy source). [See written testimony of Frederick

Warshauer, Warshauer Ex. 1, p. 4-5; see also Memo from Dean Nakano of DOWALD dated 2/1/85, State Ex. 7]

51. The heterogeneity of habitats in the "successional mosaic" ecosystem acts as partial protection from invasion by some foreign organisms by means of the relative isolation of some kipuka, foreign organisms that are limited to some degree of successional development do not have a continuous pathway of dispersal throughout that specific habitat due to its patchy occurrence. On the other hand, man-made disturbances like roads, boundary survey lines, pipelines, powerlines and trails act as conduits of dispersal for some introduced species. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, p. 8]

52. The best strategies to minimize the affects of disturbance and foreign organisms to a natural preserve include: (1) preventing man-induced physical disturbance to the native communities in the preserve; (2) minimizing disturbance near the preserve; (3) maximizing the geographic area and breadth of environmental gradients included in the preserve; (4) incorporating as many types of contiguous preservation units as possible (eg. National Park, Natural Area Reserve, Wildlife Refuge, P- and L- Subzones of conservation-zoned land) into a larger, collective preserve; (5) being true to the purposes of preservation in future land use and management decisions; (6) managing to minimize the incursion of foreign organisms and activities in preserve areas. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, p. 8]

53. In its present configuration, the WAO KELE O PUNA

NATURAL AREA RESERVE (NAR) serves to protect a portion of the WKSE. This portion is linked to that portion protected by HVNP by the Kahauale'a parcel, and is supplemented by the portions of the WKSE occurring on adjacent agriculture-zoned land. In this configuration the NAR is enhanced by the other components, and it contributes important environmental breadth as well as geographic area to what has been, by default, a larger natural preserve. The NAR also has a nothern arm outside the "successional mosaic" ecosystem that protects an example of more uniform forest in a region less subject to frequent lava flow inundation, an important comparison with the "successional mosaic" ecosystem. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, p. 9]

54. This NAR was established to preserve for future generations this particularly fine state-owned example of the biota and geologic features representative of the Kilauea east flank. In doing so, it not only includes valuable middle and low elevation portions of the "successional mosaic" ecosystem, it also has afforded it with the highest degree of administrative protection for a natural preserve that exists in Hawaii. The Natural Area Reserve System legislation is an excellent expression of and mechanism for the need to preserve for future generations examples of Hawaii's unique and wonderful natural heritage. [See written testimony of Frederick Warshauer, Warshauer Ex. 1, p. 9]

55. The proposed MER subzone fails to meet the test of an acceptable balance and compatibility of geothermal development with its current "P" or "protective" conservation land use

classification. [See oral testimony of Mae Mull, Tr., Vol V, p. 75]

G. BUFFER ZONES

56. That where residences are located should have a buffer zone of at least from one mile from potential geothermal development. [See oral testimony of Kirkendalls, Ho, Siracusa and Avery]

57. That the 2,000 foot buffer zone established to separate geotheraml subzones from Hawaii Volcanoes National Park was to conform with the "zone of influence" concept, for the purpose of avoiding drawing fluids from under Hawaii Volcanoes National Park, to protect the National Park boundary. [See oral testimony of Manabu Tagamori, Tr. Vol. IV, pp. 24-25, 37-38]

II. CONCLUSIONS OF LAW

1. The burden of proof in this case lies with DOWALD.

2. DOWALD has not met its burden of proof regarding the size or configuration of the proposed MER subzone.

3. The proposed MER subzone, which lies within a "P" or "Protective" conservation district land use classification, fails to meet the test of an acceptable balance and compatibility of geothermal development with the requirements of Act 296, where the area in question is within a conservation district.

4. The portion of the proposed MER subzone which falls within the Wao Kele 'O Puna Natural Area Reserve fails to meet the test of an acceptable balance and compatibility of geothermal development with the statutory purposes of Natural Area Reserve legislation and the requirements of Act 296 regarding social

and environmental impacts.

5. The portion of the proposed MER subzone which falls within the Wao Kele 'O Puna Natural Area Reserve fails to meet the test of an acceptable balance and compatibility of geothermal development with the statutory purposes of Natural Area Reserve legislation and the requirements of Act 296 regarding compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general pland or land use policies of the county in which the area is located.

6. The portion of the proposed MER subzone which falls within the Wao Kele 'O Puna Natural Area Reserve fails to meet the test of an acceptable balance and compatibility of geothermal development with the statutory purposes of Natural Area Reserve legislation and the requirements of Act 296 regarding permitted land uses of the county compatibility of geothermal development and potential related industries with the uses permitted under sections 18341 and 205-2, where the area falls within a conservation district.

7. That DOWALD has not demonstrated a need for a geothermal resource subzone in the MER area to fulfill the current needs of the Big Island for alternative energy production. Sufficient geothermal production is possible from the subzones which already exist in lower Puna, in the Kamaili and Kapoho subzones to meet the "known or likely prospects for utilization of geothermal resources" as required by Title 13-184-6(2), Administrative Rules of the DLNR and Act 296, SLH 1983.

8. That without assuming a particular megawatt scenario,

for example a 20 megawatt scenario or a 250 megawatt scenario, that it was impossible for DOWALD to addequately assess factors #1 [potention for production]; #2 [prospects for utilization]; #3 [geologic hazards]; #4 [environmental impacts]; #5 [compatibility of geothermal and potential related industries with uses of surrounding land and county land use policies]; and #7 [compatibility of geothermal with conservation district] listed in Act 296.

9. That the provisions in the DLNR Administrative Rules, Title 13, providing that the Board of Land and Natural Resources shall make its decision with respect to geothermal subzone designations by demonstrating "an acceptable balance" among the applicable decision making criteria, and the provisions of Act No. 296, SLH 1983, §205(b) and (c), fail to provide any meaningful standards for administrative decision making and constitutes a violation of our clients' right to appeal, equal protection of the laws, and to procedural due process as guaranteed by the Fourteenth Amendment to the United States Constitution and Article I, Section 5 of the Constitution of the State of Hawaii.

10. That the lack of meaningful standards for the Board of Land and Natural Resources decsion-making with respect to the designation of this MER subzone denies our clients the opportunity to prepare their case to adequately address the real basis for BLNR decision-making, and denies thereby our clients' procedural due process and the equal protection of the laws as guaranteed by the Constitution of the United States and the State

of Hawaii.

11. That further proceedings in the above-captioned case should be suspended until the BLNR has promulgated administrative rules pursuant to Act 296, SHL 1983 which incorporate meaningful standards for decision-making in the designation of geothermal subzones.

12. Alternatively, should a subzone be established in the MER, only 1250 acres are probably needed for development of 110 megawatts in the MER, or about 1580 acres for exploration for 150 megawatts in the MER.

Respectfully submitted,

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KENNETH KUPCHAK
Attorneys for VCA, et. al.

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone.	))))))	G.S. NO. 9/26/85-5

<u>COUNTY OF HAWAII'S</u>
<u>PROPOSED FINDINGS OF FACT,</u>
<u>CONCLUSIONS OF LAW AND DECISION AND ORDER</u>

<u>and</u>

<u>CERTIFICATE OF SERVICE</u>

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BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone.	)	G.S. NO. 9/26/85-5

COUNTY OF HAWAII'S
PROPOSED FINDINGS OF FACT,
CONCLUSIONS OF LAW, AND DECISION AND ORDER

This proceeding was brought pursuant to Act 296, SLH 1983, and Act 151, SLH 1984, Chapter 91, Hawaii Revised Statutes (HRS), and Title 13, Chapter 2, Department of Land and Natural Resources (hereinafter "DLNR") Rules of Practice and Procedure, to consider a proposal presented by DLNR, Division of Water and Land Development (hereinafter "DOWALD"), that the land area in the Kilauea Middle East Rift Zone between the western boundary of the Kamaili geothermal resource subzone and the eastern boundary of The Estate of James Campbell's lands at Kahaualea, Hawaii, be designated as a geothermal resource subzone. The contested case proceeding was conducted by the Board of Land and Natural Resources (hereinafter "BLNR") on November 13, 1985, November 14, 1985, and November 15, 1985. The BLNR, having heard the evidence and argument presented in this matter and having duly considered the records in this proceeding as well as the records in the proceedings of In the Matter of the Conservation District Use Application of the Estate of James Campbell, CDUA

No. HA-3/2/82-1463, and of In the Matter of the Designation of Kahauale'a, Puna, Hawaii, as a Geothermal Resource Subzone, GS No. 8/27/84, and the proposed findings of fact and conclusions of law, hereby makes the following findings of fact and conclusions of law.

FINDINGS OF FACT

Background

1. On December 28, 1984, the BLNR approved the designation of approximately 800 acres of surface area as a geothermal resource subzone upon the occurrence of certain events and conditions. The BLNR directed DOWALD to undertake and conduct an assessment of the Kilauea Middle East Rift Zone in and adjacent to the Natural Area Reserve beginning on the western boundary of the Kamaili geothermal resource subzone as a potential geothermal resource subzone. Although this area had not previously been evaluated due to its classification as a Natural Area Reserve, the BLNR now believes that the area should be reviewed. (State Exhibit 1; Direct Testimony of Manabu Tagamori, pp. 1, 5-7.)

2. DLNR held two public informational meetings on designating the proposed geothermal resource subzone on the island of Hawaii. The meetings were held at Keaau, Hawaii, on March 13, 1985, and at Pahoa, Hawaii, on May 15, 1985. (State Exhibit 1, pp. 7-8.)

3. On September 26, 1985, a public hearing was held at the Pahoa Neighborhood Center, Pahoa, Hawaii, to receive testimony on

the Kilauea Middle East Rift Zone as a geothermal resource subzone. (State Exhibit 1, p. 8.)

4. On September 26, 1985, Karl and Melissa Kirkendall, the Sierra Club, John Perreira, Fay Oishi, Palikapu Dedman and Emmet Aluli, Mae Evelyn Mull, and Frederick Warhauser requested that a contested case hearing be held. (Transcript of Pahoa Public Hearing of 9/26/85.)

5. On October 25, 1985, the BLNR formally approved a proposal for the Kahaualea land, identified as Tax Map Keys: 1-1-01:portion 01 and 1-2-08:01, at Kahaualea, Puna, Hawaii, consisting of 25,461.311 acres to be acquired by the State of Hawaii through an exchange with the Estate of James Campbell for State land in Puna Hawaii, identified as Tax Map Keys: 1-2-10:1, 2, and 3, consisting of 27,644.166 acres, pursuant to the Decision and Order of December 28, 1984. The designation of this area as a Natural Area Reserve will take effect upon the consummation of the land exchange, including legislative consideration of the exchange. (State Exhibit 1, p. 7; Letter dated 10/25/85 from James Detor to BLNR.)

6. On October 25, 1985, the BLNR approved the cancellation of the Governor's Executive Order No. 3103, covering the land described as Wao Kele O Puna Natural Area Reserve and identified as Tax Map Key: 1-2-10:03 at Puna, Hawaii, pursuant to the Decision and Order of December 28, 1984. The cancellation of the Natural Area Reserve designation will take effect upon the

consummation of the land exchange, including legislative consideration of the exchange. (State Exhibit 1, p. 7; Letter dated 10/25/85 from James Detor to BLNR.)

Potential of the area for the exploration, discovery, or production of geothermal resource.

7. The DLNR established a Geothermal Resources Technical Committee to assist DOWALD in its state-wide, county-by-county assessment of areas with potential geothermal resources. The committee consisted of persons with technical expertise in geothermal resources in Hawaii. (State Exhibit 2, p. 3; State Exhibit 6, pp. 1-2, Appendix C, G.S. No. 8/27/84-1.)

8. It was the consensus of the Technical Committee that current technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than three kilometers if it is to be feasible for the production of electrical energy. (State Exhibit 2, p. 3; State Exhibit 6, p. xii, 5, Appendix B, G.S. No. 8/27/84-1; State Exhibit 1, p. 10; Direct Written Testimony of Donald Thomas for Kilauea Middle East Rift GRS; Kilauea Middle East Rift hearing transcript, hereafter "KMER Tr.," V. I, pp. 38-40, 139.)

9. The Technical Committee's assessment of potential geothermal resource areas was based on a qualitative interpretation of regional surveys which used various types of data. These included groundwater temperature, geologic age, geochemistry, resistivity, infrared, seismic, magnetics, gravity,

self-potential, and exploratory drilling. (State Exhibit 2, p. 3; State Exhibit 6, pp. 3-5, G.S. No. 8/27/84-1.)

10. One of the conclusions of the Technical Committee is that no single geothermal exploration technique except exploratory drilling can positively identify the existence of a subsurface geothermal resource. (State Exhibit 2, p. 4.)

11. The Technical Committee used probability ranges, expressed in percentages, to describe potential geothermal resources. (State Exhibit 2, p. 3; State Exhibit 6, G.S. No. 8/27/84-1.)

12. The presence of a geothermal resource along the entire Kilauea Middle East Rift Zone is indicated by currently available geotechnical data. Evaluation of data indicated that the probability for finding a high temperature geothermal resource, as defined by the Technical Committee, on the entire Kilauea rift zone is greater than 90%. Evaluation further suggested a greater than 90% probability along the currently visible surface expression of the rift zone with a gradual decline in probability out to the extent of an aeromagnetic anomaly. The aeromagnetic anomaly associated with the rift zone indicates temperatures in excess of 500°C present at shallow depths. (State Exhibit 2, p. 3; State Exhibit 6, G.S. No. 8/27/84-1.)

13. Additional considerations relating to the Kilauea Middle East Rift Zone were brought out following the completion of the Technical Committee's state-wide, county-by-county assessment.

These are that temperatures greater than 500°C may be present at depths of two to three kilometers out towards the limits of the 25% probability line and the suggestion that the rift zone has migrated in a southerly direction to its present active location and is much broader in the northward direction than its present surface expression. (State Exhibit 2, p. 4.)

14. The delineation of potential geothermal resources is expressed as mapped 90% and 25% probability contour lines. The area of potential high temperature resource is denoted within the 90% probability lines. Areas between the 90% and 25% probability lines represent decreasing probability, or a gradation, of finding a high temperature resource. (State Exhibit 2, pp. 4-5; State Exhibit 4; State Exhibit 6, G.S. No. 8/27/84-1.)

15. The proposed Kilauea Middle East Rift geothermal resource subzone centers on an area with a 90% probability for finding a geothermal resource. (State Exhibit 2, p. 5; State Exhibit 11, p. 10; State Exhibit 4.)

16. The southerly subzone boundary closely follows the 90% probability line. The northerly subzone boundary extends beyond the 90% probability line but is still within the 25% probability line. DOWALD determined that the proposed northerly boundary is a reasonable distance north of the rift zone to provide areas that are less susceptible to geologic hazards, particularly lava flows, than areas to the south of the rift zone. (State Exhibit 1, pp. 19-20; KMER Tr., V. IV, pp. 166-168.)

17. The proposed subzone encompasses an area with a high probability for finding a geothermal resource. (State Exhibit 4.)

<u>Prospect for utilization of geothermal resources for electrical energy production and distribution</u>.

18. Existing State law defines geothermal development activities as the exploration, development, or production of electrical energy from geothermal resources. HRS §205-5.1(a). Geothermal development generally follows exploration and confirmation of a commercially usable geothermal resource. Exploration should most logically occur in areas where there is a high probability for finding a geothermal resource. (State Exhibit 6, G.S. No. 8/27/84-1.)

19. The Hawaii Electric Light Company (hereinafter "HELCO") has a goal of becoming independent of oil-fired generators. About 60% of the electricity produced on the island of Hawaii is generated from fossil fuels such as industrial and diesel fuel oils. However, due to the uncertainties of the price and supply of fuel oil, HELCO is seeking to ultimately meet system demands solely from energy sources such as geothermal, hydroelectric, biomass, wind, solar, and OTEC. Oil-fired generators would be used for emergencies. (Nakamura, Applicant's Exhibit 9, p. 2, CDUA No. HA 3/2/82-1463; KMER Tr., V. IV, pp. 109-114.)

20. By 1991, HELCO could conceivably need an additional 26 MW of electrical power. (KMER Tr., V. IV, p. 121.)

21. HELCO would need in excess of 100 MW of power in 1990 if it were to replace or shut down all of the oil-fired units within its system. (KMER Tr., V. IV, p. 127.)

22. Geothermal is considered by HELCO to be the most reliable of the various energy sources that could be used as an alternative to fossil fuels. (KMER Tr., V. IV, pp. 113-114.)

Potential geologic hazards to geothermal production or use.

23. Geology is not an exact science. (Volcano Community Association, hereinafter "VCA," Exhibit 218, p. 3, CDUA No. 3/2/82-1463; Written Testimony of Robert Decker.)

24. Although past history of geologically hazardous events could give some idea of future events, it is difficult or impossible to accurately predict the future occurrence of geologic hazards with any degree of scientific certainty. (State Exhibit 12, p. 18, G.S. No. 8/27/84-1.)

25. The volcanic activity which provides the source of geothermal heat may also create a hazard to people and property. (State Exhibit 12, p. vii, G.S. No. 8/27/84-1.)

26. Kilauea Volcano's East Rift Zone is a zone of intense volcanic activity and is marked by a series of eruptive vents, fault scarps, and prehistoric and historic cinder cones, all of which are surficial features indicative of volcanic activity. The zone varies in width from two to four miles. (Environmental Impact Statement, hereinafter "EIS," from CDUA No. HA 3/2/82-1463, pp. 3-7, D-4, D-5, Fig. 71.)

27. Some portions of the proposed subzone lack any soil and are characterized as barren lava flows. (State Exhibit 4.)

28. The hydrology is unique in the Kilauea East Rift Zone, the hydrology is unique. The geothermal reservoir's thermal and permeability properties allow fluids to rise near the surface and to be mixed very rapidly through the geothermal system. In addition, as the result of vertical diking and fracturing that run east and west, there is high permeability in vertical and east-west directions; this causes damming or redirection of groundwater flow. A high head of water exists north of the rift zone, whereas to the south of the rift zone, the groundwaters are at or near sea level. (Tr., V. II, pp. 348-49, CDUA No. HA 3/2/82-1463.)

29. The primary hazard along the rift zone consists of eruptions and lava flows, pyroclastic fallout, earthquakes, and sudden ground movement associated with faulting. (EIS, CDUA No. HA 3/2/82-1463, pp. 5-31.)

30. Geothermal development investors bearing the economic risk of loss resulting from geologic hazards have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity. The State in the conservation district or counties in the urban, rural, or agriculture districts may impose conditions to be met by the developers to clarify the applicant's risks of loss. (State Exhibit 12, G.S. No. 8/27/84-1, pp. 8, 9.)

Hazards from eruptions and lava flows.

31. Kilauea's East Rift Zone has been volcanically active up to the present time. The entire East Rift Zone has a substantial risk of lava flow burial in areas close to the axis of the rift. (State Exhibit 12, G.S. No. 8/27/84-1, pp. 19-20, 28-30, 32.)

32. Since 1750 there have been more than 20 eruptions within the Kilauea East Rift Zone. (State Exhibit 12, G.S. No. 8/27/84-1, p. 19.)

33. The southern portion of the rift zone is more prone to be covered by lava flows than the northern portion. (State Exhibit 12, pp. 29-30.)

34. Most of the proposed subzone has not been covered by lava flows for at least 350-500 years. (VCA Exhibit 215, Holcomb Map, CDUA No. HA 3/2/82-1463.)

35. Several construction techniques are available which may mitigate the damage caused by lava flows. These include strategic siting, diversion berms and barriers, enclosed well cellars, evacuation planning, use of "bridge plugs," and decentralization of power plants to lessen the chance of one lava flow damaging a large capacity plant. A thorough evaluation of these mitigation alternatives can be provided prior to decisions on future geothermal development permits. (State Exhibit 12, G.S. No. 8/27/84-1, pp. 5, 12.)

Hazards from pyroclastic fallout.

36. The weight and depth of fallout can be appreciable as far as even 500 or 1,000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent, building cones that may be tens of meters high. Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent. (State Exhibit 12, G.S. No. 8/27/84-1, p. 2.)

37. In 1959 a blanket of pyroclastic fallout from Kilauea Iki vent in Kilauea's upper east rift zone extended approximately 3,000 meters south of the rift. (State Exhibit 12, G.S. No. 8/27/84-1, p. 21.)

38. Prevailing easterly trade winds are likely to carry fallout originating within the rift zone away from the Kilauea Middle East Rift Zone in a westerly direction. (State Exhibit 2, Fig. 2-3.)

39. Protecting structures or machinery against damage by pyroclastic fallout might be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should have a sufficient pitch so that pyroclastic fallout does not accumulate. (State Exhibit 12, G.S. No. 8/27/84-1, p. 7.)

Hazards from earthquakes.

40. Most earthquakes in Hawaii are volcanic, resulting from near-surface magma movements. They are small in magnitude and usually cause little direct damage. (State Exhibit 12, G.S. No. 8/27/84-1, p. 4.)

41. Earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983. (State Exhibit 12, G.S. No. 8/27/84-1, p. 27.)

42. The largest recent earthquake had a magnitude of 7.2 and occurred in 1975 about 5 kilometers southwest of Kalapana. (State Exhibit 12, G.S. No. 8/27/84-1, p. 18.)

43. Geothermal power plants should be constructed to withstand an earthquake of 7.5 magnitude. (State Exhibit 12, G.S. No. 8/27/84-1, p. 8.)

Hazards from ground cracking and subsidence.

44. Cracking and subsidence related to magma movements are concentrated in the volcanic rift zones which are clearly defined and are narrow features along the entire Kilauea East Rift Zone. (State Exhibit 12, , G.S. No. 8/27/84-1, pp. 3, 22, 35.)

45. Ground subsidence has historically been limited to the rift zone itself or to areas south of rift zone. (EIS p. D-11; Applicant's Exhibit 2, pp. 13, 15; CDUA No. HA 3/2/82-1463.)

46. Intrusion of magma at Kilauea, sometimes leading to eruptions, often produces offsets of the ground to great depths along the rifts of the volcano. Such offsets do not necessarily occur on vertical surfaces, and the potential for offsetting geothermal well bores drilled in these periodically active areas exist. If cased well bores are cut at depth, then pathways to the surface could be opened through which gasses from a deep

geothermal system might escape. (VCA, Exhibit 7, G.S. No. 8/27/84-1.)

47. Most cracks are vertically pitched making it unlikely, but possible, that a vertical crack would intercept a vertical well bore. (State Exhibit 12, G.S. No. 8/27/84-1, pp. 3, 4.)

48. Hazards from ground cracking and subsidence have been mitigated to an extent by locating the proposed Kilauea Middle East Rift geothermal resource subzone north of the rift zone axis. (State Exhibit 1, pp. 11, 19-20.)

Social and Environmental Impacts.

49. The social impact analysis of the geothermal resource area along the Kilauea Middle East Rift Zone considers people's perceptions, attitudes, and concerns regarding geothermal resource development activities. (State Exhibit 2, p. 7.)

50. The analysis was based on currently available public information concerning health, noise, lifestyle, culture, community setting, aesthetics, and community input. (State Exhibit 2, p. 7.)

51. New residents associated with geothermal development may be a small part of lifestyle, culture, and community changes already evident in the Puna area. (State Exhibit 2, p. 12.)

52. Prehistoric cultural activities and features have been reported in the area adjacent to the proposed geothermal subzone. (State Exhibit 2, p. 12.)

53. Subsequent permitting processes exist for the analysis of and the avoidance or mitigation of potential impacts from geothermal developments. (State Exhibit 5.)

54. The proposed geothermal resources subzone is currently little used as an economic entity as there are few residents and economic activities in the proposed subzone. (Kirkendall Exhibit 1-4; State Exhibit 4.)

55. In its present state, it provides open space to the residents of adjacent residential and agricultural subdivisions. (Kirkendall Exhibit 1-4; State Exhibit 4.)

56. Elements of major social concerns and impacts could be minimized and maintenance of a quality environment could be achieved by proper siting, landscaping, aesthetic facility design, and careful controls and monitoring. (State Exhibit 8, G.S. No. 8/27/84-1, p. 17.)

57. There are practitioners of Hawaiian religion who worship the goddess Pele. (State Exhibit 2, p. 12; KMER Tr., V. V, pp. 122-124, Aluli/Dedman Exhibits 1 and 2.)

58. These practitioners believe that geothermal development is harmful to Pele and their religious practices. (Aluli/Dedman Exhibits 1 and 2; KMER Tr., V. V, pp. 119-167; KMER Tr., V. VI, pp. 4-36.)

59. Writings indicate that early Hawaiians used geothermal energy in the form of steam from fissures for cooking and/or worship. (State Exhibit 2, p. 13.)

60. Factors associated with geothermal development which have a possible effect on the environment include air emissions, liquid effluent, noise, visual aesthetics, and physical disturbance during construction. (State Exhibit 2, p. 19.)

61. Regarding possible harm from air emissions, the State Department of Health has and will continue to set standards necessary to protect the public health. (State Exhibit 2, p. 19.)

62. Hydrogen sulfide is a gas which affects the membranes of the eye and respiratory tract. (State Exhibit 2, p. 23.)

63. Available information on the long term effects of hydrogen sulfide exposure has revealed no evidence of health impairments at levels even above the air quality standards established in California. (State Exhibit 2, p. 25.)

64. The flora of the Kilauea Middle East Rift Zone was assessed using a forest categorization system based on United States Fish and Wildlife Service vegetation type mapping which incorporates information on the extent of canopy cover, height of canopy, understory composition, and vegetation association type. (State Exhibit 2, Fig. 7; State Exhibit 13.)

65. Disruption of native forest ecosystems is a potential environmental impact from the development of geothermal energy. (State Exhibit 3, p. 116.)

66. Specific information on development proposals is necessary to accurately predict impacts on native forest ecosystems. (KMER Tr., V. IV, p. 218; State Exhibit 3, p. 116.)

67. Impact to native forest ecosystems can be minimized by employing certain mitigating measures. Through the careful siting of facilities, access roads, and pipe and powerline corridors, damage to biologically valuable forest could be avoided. (State Exhibit 3, p. 116.)

68. Endangered birds, including the O'u, I'o, and Nene have been sighted on the middle east flank. (State Exhibit 1, p. 17.)

69. The lower elevation boundary for the O'u essential habitat has been set at 2,000 feet. (State Exhibit 2, G.S. No. 9/26/85-5, p. 17.)

70. Only a small portion of the proposed geothermal resource subzone is above 2,000 feet elevation and, therefore, the proposed geothermal subzone should not impact on the survival of the O'u. (State Exhibit 1, p. 17; KMER Tr., V. II, pp. 48-50, 65-71.)

71. The I'o has been seen in a wide range of ecosystems other than the proposed geothermal resource subzone. (State Exhibit 2, p. 17.)

72. Nene are not known to nest in the proposed geothermal resource subzone. (State Exhibit 2, p. 17.)

<u>Compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located</u>.

73. The great majority of the land within the proposed Kilauea Middle East Rift geothermal resource subzone is designated conservation by the State Land Use Commission. (State Exhibit 2, p. 17.)

74. A small part of the proposed subzone in the extreme eastern and southeastern areas is within the state land use agricultural district. (Exhibit 2, p.17.)

75. Act 296, SLH 1983, as amended by Act 151 1984, allows the designation of geothermal resource subzones within urban, rural, agricultural, and conservation state land use districts established under §205-2, HRS. (State Exhibit 2, p. 17.)

76. As to the land within the proposed subzone which is classified agriculture and therefore under the jurisdiction of the County, the County of Hawaii has permitted the drilling of geothermal wells in lands zoned agricultural near the HGP-A geothermal facility. (State Exhibit 2, p. 18.)

77. With regard to the lands designated agricultural, the County will assess the propriety of specific geothermal development proposals in its permitting process. (State Exhibit 2, p. 18; County of Hawaii Exhibit 1.)

78. For conservation lands, the BLNR will further assess compatibility during proceedings for a conservation district use permit. (State Exhibit 2, p. 18.)

79. Monitoring, observing, and measuring natural resources are permitted uses in the protective subzone. (Section 13-2-11(c)(6), "Administrative Rules of the Department of Land and Natural Resources, State of Hawaii, Providing for Land Use Within the Conservation District, Providing for Subzones, Uses, Appeals, Enforcement and Penalty, Pursuant to Chapter 183-41, Hawaii Revised Statutes, As Amended.)

Potential Benefits to be derived from geothermal development and utilization.

80. The County of Hawaii General Plan is the County's official policy for the long-range comprehensive physical development of the island of Hawaii. (County Exhibit 1; County Exhibit 2.)

81. The current County General Plan was initially adopted as Ordinance No. 439 on December 15, 1971. (County Exhibit 2.)

82. Amendments to the General Plan ordinance based on a revision and up-date program were made in 1979 and 1980. (County Exhibit 2, Revisions insert.)

83. These amendments included the addition of an Energy Element to the General Plan document. This addition was based on the recognition of the County's vulnerability to dislocations in the global petroleum market, its dependence on imported fossil fuels, and the potential of the island's natural energy resources. (County Exhibit 2, Revisions insert, pp. 7-11.)

84. The Energy Element of the General Plan sets forth two goals. One is to strive towards energy self-sufficiency for the County and the other is to establish the island as a demonstration community for the development and use of natural energy resources. (County Exhibit 2, Revisions insert, p. 11.)

85. The Energy Element also contains policies for the County to pursue towards attaining the goals for this element. These include, among others, encouraging the development of alternative energy resources, encouraging the expansion of the energy research

industry, and ensuring a proper balance between the development of alternative energy resources and the preservation of environmental fitness. (County Exhibit 2, Revisions insert, p. 11.)

86. The Economic Element of the General Plan sets forth goals for the County which state that the County's economic system should provide residents with opportunities to improve their quality of life, that economic development and improvement should be accomplished in an orderly manner which is in balance with the physical and social environments of the island, and that the County should strive for stability in its economic system. (County Exhibit 2, p 11.)

87. Policies to pursue in order to strive towards the goals of the Economic Element include, among others, striving for an economic climate which provides residents of the County an opportunity for choice of occupations; encouraging the expansion of the research and development industry by working with and supporting the university and other agencies' programs developed to aid the County; requiring a study of the total social and physical impact of large developments prior to their approval; and striving for diversification of the County's economy by strengthening existing industries and attracting new endeavors. Another policy is that the County's land, water, air, sea, and people shall be considered as essential economic resources for present and future generations and should be protected and

enhanced through the use of economic incentives. (County Exhibit 2.)

88. The Natural Resources and Shorelines Element of the General Plan defines natural resources as those physical facts in our environment which are recognized as useful, valuable, and desirable in our lives. They are basically land, water, and air and include flora and fauna, soils, geologic features, and the shoreline. (County Exhibit 2, p. 45.)

89. The goals of the Natural Resources element call for the protection and conservation of natural resources from undue exploitation, encroachment and damage as well as for providing opportunities for the public to fulfill recreational and educational needs without despoiling or endangering natural resources. Policies to implement these goals include the County requiring that users of natural resources conduct their activities in a manner that avoids or minimizes adverse effects on the environment, and the County coordinating programs to protect natural resources with other government agencies. (County Exhibit 2, p. 44.)

90. In the County planning process, the General Plan provides overall long-range general policies for development. The various goals, policies and standards of all the General Plan elements need to be reviewed and addressed in reviewing proposals and projects. The goals and policies are also further refined and become more specific through middle and short-range plans and

through implementing tools, such as land development codes and capital improvement projects. (County Exhibit 2, Revisions insert, pp. 2-7.)

91. At the General Plan level, applicable goals and policies support the exploration and development of geothermal resources in a manner which does not unduly despoil, damage, or endanger the island's natural resources.

92. The County recognizes the potential benefits it may derive from the development of geothermal resources and has supported such development as being consistent with its General Plan. (State Exhibit 6, County Testimony at Public Hearing.)

93. The County further recognizes that subsequent to the designation of a geothermal resource subzone specific development proposals will be formulated and available for intensive review and analysis prior to their approval. Such specific proposals are analyzed relative to all General Plan elements as well as other appropriate County plans and policies, including social, environmental and fiscal impacts. With a specific proposal, economic benefits and costs, impacts upon infrastructure, and other factors can be predicted. (County Exhibit 1; County Exhibit 2; County Recommendations in Support of Designation of Kahaualea, Puna, Hawaii, as a Geothermal Resource Subzone.)

CONCLUSIONS OF LAW

Based upon the foregoing and upon Chapter 91, HRS, Sections 205-5.1 and 205-5.2, HRS, as amended, and Title 13, Chapter 2, DLNR Rules, the BLNR concludes:

1. That the area of the proposed geothermal subzone demonstrates an acceptable balance among the following factors:

a. The area's potential for the production of geothermal energy.

b. The prospects for the utilization of geothermal energy in the area.

c. The geologic hazards that potential geothermal projects would encounter.

d. Social and environmental impacts.

e. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the County in which the area is located.

f. The potential economic benefits to be derived from geothermal development and potential related industries.

g. The compatibility of geothermal development and potential related industries with the uses permitted under Sections 183-41 and 205-2 for the area of the proposed subzone which falls within a conservation district. HRS §§205.2(b)1-7.

2. For the area of the proposed subzone which is in a conservation district, designation as a geothermal resource subzone is appropriate and will not be detrimental to the conservation of necessary forest growth, the conservation of water resources adequate for present and future needs, and the conservation and preservation of open space for public use and enjoyment. §183-41(c)(3), HRS.

3. For the area of the proposed geothermal resource subzone which falls within the state land use conservation use district, designation as a subzone is not incompatible with or detrimental to a multiple use conservation concept. §205-2, HRS; §13-2-11, DLNR Rules.

4. Public hearings conducted by the BLNR were held pursuant to proper notice in accordance with HRS §205-5.2(d)(1) and §13-184-8, DLNR Rules.

5. Parties who initiated the contested case proceeding by request have, pursuant to §91-10, HRS, the burden of proof and have failed to discharge this burden of proof on all issues raised in this proceeding.

6. Intervenors Aluli and Dedman have failed to show that the designation of the subject area as a geothermal resource subzone would interfere with the religious practices and those who worship the goddess Pele.

7. That in evaluating the designation of the area as a geothermal resource subzone, the BLNR found an acceptable balance of the following criteria:

a. That the area has known or plausible potential for the exploration, discovery, or production of geothermal resource.

b. That there is a known or likely prospect for the utilization of geothermal resources for electrical energy production and distribution.

c. That any potential geologic hazards to geothermal production or use in the proposed area (are)(have been) examined.

d. That any environmental or social impacts of the development of geothermal resources within the proposed area (be)(have been) considered.

e. That the compatibility of development and utilization of geothermal resources within the proposed area (has been)(is) considered with other allowed uses within the area and within the surrounding lands.

f. That the potential benefits to be derived from geothermal development and utilization in the proposed area (be)(is) in the interest of the county involved and the State as a whole. §§13-184-6(1)-(6), BLNR Rules.

ORDER

Accordingly, the BLNR hereby designates as a geothermal resource subzone the area presented in the proposal by DOWALD in State's Exhibit 4.

Dated: Hilo, Hawaii, December 4, 1985.

COUNTY OF HAWAII

By Patricia K. O'Toole
PATRICIA K. O'TOOLE
Deputy Corporation Counsel

Its Attorney

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that a copy of the foregoing document was served upon the following by having the same hand-delivered on December 4, 1985:

SUSUMU ONO
1151 Punchbowl Street
Honolulu, Hawaii 96813
Chairman, Board of Land
and Natural Resources of the
State of Hawaii

I HEREBY CERTIFY that copies of the foregoing document were served upon the following by mailing the same, postage prepaid, on December 4, 1985:

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County of Hawaii

The Division of Water and Land Development, having been assigned the task, and in accordance with the provisions of Act 296, SLH 1983, adn 151, SLH 1984, conducted an assessment of the Kilauea Middle East Rift for designation as a geothermal resource subzone.

The division staff ~~These individuals~~ relied upon the available information which has been compiled in the following documents as presented in the previous Contested Case Hearing on Kahaualea (G.S. No. 8/27/84-1).

Circular C-103, Statewide Geothermal Resource Assessment	(State Exhibit No. 6)
Circular C-104, Social Impact Analysis of Potential Geothermal Resource Areas	(State Exhibit No. 8)
Circular C-105, Economic Impact Analysis of Potential Geothermal Resource Areas	(State Exhibit No. 9)
Circular C-106, Environmental Impact Analysis of Potential Geothermal Resource Areas	(State Exhibit No. 10)
Circular C-107, Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas	(State Exhibit No. 12)
Circular C-108, Geothermal Technology	(State Exhibit No. 11)

The staff then conducted an assessment of the Middle East Rift based on factors set out in Act 296, SLH 1983.

As Manager and Chief Engineer for the division, I relied on the staff expertise and with them completed the assessment and formulated the recommendation presented in current State Exhibits, No. 1 and 2.

B. Presentation Approach

I will briefly describe the background of activities leading up to the current proposal. I will then focus on the assessment of the Kilauea Middle East Rift as recommended geothermal resource subzone.

II. BACKGROUND

A. State Energy Goals and Objectives

Act 296 specifies that the Board of Land and Natural Resources shall consider the provisions of Chapter 226, the Hawaii State Planning Act. The ~~General~~ provisions of this act apply to energy, generally and to geothermal resources, in particular.

Act 226 sets both overall and specific goals, objectives and policies. To achieve the overall theme of individual and family self-sufficiency, social and economic mobility, community and social well-being, a number of "State Goals" must be achieved. (State Exhibit No.14, G.S. No. 8/27/84-1)

The State goals include the following:

(1) A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.

(3) Physical, social, and economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, or caring and of participation in community life.

Specific objectidves for utility systems are also stated in Act 226 and include:

(1) Dependable, efficient, and economical statewide energy and communcation systems capable of supporting the needs of the people.

(2) Increased energy self-sufficienty.

To achieve these objectives, the following policies are to be implemented:

(1) Accelerate research development and use of new energy sources.

(2) Provide adequate, reasonably priced, and dependable power and communication services to accommodate demand.

(3) Ensure a sufficient supply of energy to enable power systems to support the demands of growth.

(4) Promote prudent use of power and fuel supplies through education, conservation and energy-efficient practices.

(5) Ensure that the development or expansion of power systems and sources adequately consider environmental, public health, and safety concerns, and resource limitations.

(6) Promote the use of new energy sources.

(7) Facilitate the development and use of improved communications technology.

Chapter 226 also establishes an overall priority direction and implementing actions to address areas of statewide concern. Priority actions for energy use and development ~~(specified~~ include:

(1) Encourage the development of alternate energy sources.

(2) Encourage development of a program to promote conservation of energy use in the State.

(3) Encourage future urbanization into easily serviceable, more compact, concentrated developments in eixsting urban areas wherever feasible to maximize energy conservation.

(4) Encourage consumer education programs to reduce energy waste and to increase awareness for the need to conserve energy.

(5) Encourage the use of energy conserving technology and appliances in homes and other buildings.

(6) Explore possible incentives to encourage the use of alternate energy sources in homes and other buildings.

(7) Encourage the development and use of energy and cost-efficient transportation systems.

The Hawaii State Planning Act also provides for the formulation of Functional Plans in twelve functional areas of services provided by the State government. One such area specified is in the functional area of energy.

The State Energy Functional Plan sets forth specific objectives and policies for development of alternate energy resources. They are:

<u>OBJECTIVE</u>: Accelerate the Transition to an Indigenous Renewable Energy Economy by Facilitating Private Sector Activities to Explore Supply Options and Achieve Local Commercialization and Application of Appropriate Alternate Energy Technologies.

Hawaii's near-total dependence on imported petroleum, spiraling oil prices, the net outflow of dollars for oil payments, and the political unrest of major oil-producing nations threaten local economic stability and the ability to serve energy needs over time. Support and assistance for private sector activities to develop local energy resources will reduce dependence on the world oil market, improve the State's balance of payments, and thus promote economic development, and increase the number and diversity of employment opportunities.

To achieve this objective the following policies which apply directly to geothermal energy are stated:

<u>POLICY</u>: Investigate and alleviate non-technical (legal/institutional/ economic/financial) barriers to alternate energy resource development.

<u>IMPLEMENTING ACTION</u>: GEOTHERMAL ENERGY - Support continued implementation of the State Geothermal Commercialization Program to address and mitigate legal and institutional concerns.

<u>POLICY</u>: Facilitate research, development and demonstration activities designed to resolve remaining technical barriers to alternate energy technologies in order to expedite local commercialization.

<u>IMPLEMENTING ACTION</u>: Continue statewide alternate energy resource assessment studies as appropriate to supplement private sector investigations.

<u>IMPLEMENTING ACTION</u>: GEOTHERMAL ENERGY - Continue geothermal research activities as appropriate to support commercialization efforts.

Quite clearly, the designation of geothermal resource subzones is an essential step in achieving the Hawaii State Planning Act goals and in particular, the goals of increased energy self-sufficiency.

B. <u>Act 296, SLH 1983</u>

Act 296, SLH 1983 directs the Board of Land and Natural Resources to designate geothermal resource subzones to assure that the interest in developing geothermal resources is balanced with the interest in preserving Hawaii's unique social and natural environment.

The Act provides seven assessment factors or criteria for evaluating potential geothermal resource subzones. These factors include, but are not limited to:

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BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii as a Geothermal Resource Subzone	G.S. NO. 9/26/85-5

TESTIMONY FOR THE
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
ON THE PROPOSAL OF
THE KILAUEA MIDDLE EAST RIFT ZONE
AS A GEOTHERMAL RESOURCE SUBZONE

I. INTRODUCTION

A. Background/Qualifications of Manabu Tagomori

Mr. Chairman and Members of the Board of Land and Natural Resources, the Division of Water and Land Development is responsible for the recommendation on the designation of the Kilauea Middle East Rift Zone as a geothermal resource subzone for the Department of Land and Natural Resources. I will be presenting the Department's testimony on the designation of the Kilauea Middle East Rift as a Geothermal Resource Subzone.

I am a registered professional engineer in the State of Hawaii in the Civil branch. I have been employed by the Department for over 28 years and have served as Study Manager of an inter-governmental Hawaii Water Resources Regional Study, Executive Secretary of the State Water Commission, Chief Water Resources and Flood Control Engineer of the Division and since January 1985, the Manager-Chief Engineer of the Division of Water and Land Development.

The Division is responsible for the management, regulation and protection of Hawaii's water and mineral resources and the planning and development of water projects. The Division, under my direction and administration, monitors and regulates all exploratory drilling for water and geothermal resources, including the inventory of mineral resources and mining activities in the State.

✓ On December 28, 1984, the Board of Land and Natural Resources rendered a Decision and Order (D/O) on the proposed geothermal resource subzone at Kahaualea, Hawaii. The D/O directed the Department of Land and Natural Resources to evaluate the Kilauea Middle East Rift Zone as a potential geothermal resource subzone.

(1) Potential geothermal energy production
(2) Use of geothermal energy in the area
(3) Geologic hazards
(4) Social and environmental impacts
(5) Compatibility with present and planned use
(6) Potential economic benefits
(7) Compatibility with conservation principles where a subzone falls within a conservation district.

The assessment may be based on currently available public information.

C. Act 151, SLH 1984

Act 151, SLH 1984, signed into law on May 25, 1984, clarifies some of the provisions of Act 296, SLH 1983, as follows:

- Permits geothermal development activities within urban, rural, agricultural, and conservation land use districts.
- Defines geothermal development as "the exploration, development or production of electrical energy from geothermal resources."
- Existing leases within an agricultural district which were issued a special use permit by the County for geothermal development activities, is declared a geothermal resource subzone for the duration of the lease.

D. Previous Subzone Designations

As of November 16, 1984, the Board of Land and Natural Resources has designated the following areas as geothermal rsource subzones. The Kapoho Section includes three existing geothermal mining leases.

	Area (acres)
Haleakala Southwest Rift, Island of Maui	4,108*
Kilauea Lower East Rift (Kamaili Section), Island of Hawaii	5,405*
Kilauea Lower East Rift (Kapoho Section), Island of Hawaii	5,211*

*Approximate Acreage

In addition, the Board now proposes to designate the Kilauea Middle East Rift as a Geothermal Rsource Subzone.

E. Board of Land and Natural Resources Decision and Order of December 28, 1984

In the Decision and Order on the previously proposed geothermal resource subzone at Kahaualea, in the Kilauea Upper East Rift, issued December 28, 1984, the Board approved the designation of approximately 800 acres of surface area as a geothermal resource subzone upon the occurrence of the following events and upon the following conditions:

- o The cessation of volcanic activity in, around, and near the area permitted by the Board's February 25, 1983 Decision and Order. The determination that eruptive activity constituting a geologic hazard has ceased shall be made by the Board upon evidence and testimony from professional geologists from the Hawaii Volcanoes Observatory and the U.S. Geological Survey. Other professional geologists with special experience in this particular geographic area may be heard at the Board's discretion.

- o No new activity associated with the permitted area shall be considered until after the determination is made that geologically hazardous and eruptive activity in, near, and around the permitted area has ceased as provided for above.

- o At that time, the Board representing the State of Hawaii, formally requested the Estate of James Campbell to investigate and consider a land exchange involving State owned land in Kilauea middle east rift zone and Campbell Estate's lands at Kahaualea (excluding Tract 22).

- o If the State of Hawaii and Campbell Estate should later consummate a land exchange involving lands at Kahaualea for State or other lands upon which geothermal activities may take place, then the geothermal subzone designation in the Decision and Order shall cease to exist and shall have no froce or effect in law, notwithstanding any further requirement for a contested case hearing in HRS 205-5.2(3) or any other provision of law to the contrary.

- o The Board of Land and Natural Resources on its own motion directed the Division of Water and Land Development DOWALD of the Department of Land and Natural Resources (DLNR) to immediately undertake and conduct an assessment of ther Kilauea middle east rift zone in and adjacent to the Natural Area Reserve beginning on the western boundary of the Kamaili geothermal subzone as a potential geothermal resource subzone. Although this area had not previously been evaluated due to its classification as a Natural Area Reserve, the Board now believes that the area should be reviewed.

- o If a) the assessment of the Kilauea middle east rift zone does not result in a designation as a geothermal resource subzone in this area; or b) a land exchange between the State of Hawaii and the Estate of James Campbell is not consummated then the remainder of the 5300 acres proposed by DOWALD as a geothermal resource subzone in Kahaualea heretofore not designated by this Decision and Order shall be and is hereby ordered to be so designated as a geothermal resource subzone.

- If the land exchange described above is consummated, the Board of Land and Natural Resources strongly urges the federal government and the National Park Service to immediately seek to acquire Tract 22 (as described on its Master Plan), which the State will not itself seek.

- If the exchange described above does occur, the entire 5300 acres within the proposed subzone (exclusive of Tract 22) shall be included within the lands acquired by the State of Hawaii from Campbell Estate and shall be eliminated from the proposed subzone.

F. Board Action Following the Decision and Order of December 28, 1984.

On October 25, 1985, the Board formally set aside the Kahaualea land identified as Tax Map Key: 1-1-01:portion 01, at Kahaualea, Puna, Hawaii, consisting of 16,293.111 acres to be acquired by the State of Hawaii in exchange with the Campbell Estate pursuant to the Decision and Order of December 28, 1984.

The designation of this area as a Natural Area Reserve will take effect upon the consummation of the land exchange including legislative consideration of the exchange.

On October 25, 1985, the Board ~~also cancelled~~ approved the cancellation of the Governor's Executive Order No. 3103, covering the land described as Wao Kele O Puna Natural Area Reserve and identified as Tax Map Key: 1-2-10:03 at Puna, Hawaii, pursuant to the Decision and Order of December 28, 1984.

The cancellation of the Natural Area Reserve designation will take effect upon the consummation of the land exchange including legislative consideration of the exchange.

III. PUBLIC PARTICIPATION

Throughout the assessment process, public comment and participation has been invited from interested parties.

Two public informational meetings on designating the proposed geothermal resource subzone were held by the State Department of land and Natural Resources on the island of Hawaii. The meetings were held at Keaau, Hawaii, on March 13, 1985 and at Pahoa, Hawaii, on May 15, 1985.

The first meeting identified the most likely locations of geothermal resources; the second meeting focused on the identification of impact issues.

To ensure full public participation, the time, place and purpose of these meetings were announced in newspaper publications, radio announcements, and letter invitations.

In addition, on July 29, 1985, the Department mailed letters to concerned parties requesting written comments and information on the proposed GRS.

On September 26, 1985, a public hearing was held at the Pahoa Neighborhood Center, Pahoa, Hawaii, to receive testimony on the Kilauea Middle East Rift Zone as a geothermal resource subzone.

IV. BASIC FACTS AND ASSUMPTIONS

- The Board of Land and Natural Resources, by its Order of December 28, 1984, has directed the Division of Water and Land Development to assess the subzone potential of of the Kilauea middle east rift zone in and adjacent to the Wao Kele O Puna Natural Area Reserve beginning on the western boundary of the Kamaili geothermal subzone.

- Act 296, HRS 1983, does not require an environmental impact statement for subzoning but states that the assessment may be based on currently available information.

- There is only a very limited amount of land within the state suitable for subzone designation. Less than 1% of the state's total land area has been designated or proposed as a Geothermal Resource Subzone. It cannot be guaranteed that land areas designated as subzones will provide any certain amount of geothermal capacity.

- The subzoning process is a broad land-use designation. All subsequent geothermal activities require State or County development permits. These permits will likely require a thorough site-specific analysis and an Environmental Impact Statement when specific facts about a proposed development are known. At such time a proposal for specific geothermal development can be accepted, rejected, or modified to assure development only in an environmentally acceptable manner.

- Buffer zones have been used throughout the subzoning process to minimize any potential environmental impacts to the National Park and surrounding areas. In addition, directional drilling technology can tap geothermal resources at depth while causing minimal disturbance to surface areas directly above.

V. ASSESSMENT OF THE KILAUEA MIDDLE EAST RIFT

A. Statewide Geothermal Resource Assessment

In 1984, the Geothermal Resources Technical Committee consisting of individuals with expertise in engineering geochemistry, reservoir engineering, geology, geophysics and hydrology, undertook a county-by-county evaluation of potential geothermal resource areas based on the following data: groundwater temperature, geologic age (in terms of recent eruptive activity and surface features inferring resource presence), geochemistry, resistivity, infrared surveys, seismic surveys, magnetics, gravity, exploratory drilling and self-potential data (natural voltage anomalies). An indepth description of this assessment is provided in the previous State Exhibit 6, DLNR Circular C-103, titled "Statewide Geothermal Resource Assessment", G.S. No. 8/27/84-1.

Seven high temperature areas with potential for production of electrical energy were identified. They are:

(1) Haleakala S.W. Rift Zone, Maui
(2) Haleakala East Rift Zone, Maui
(3) Hualalai, Hawaii
(4) Mauna Loa S.W. Rift Zone, Hawaii
(5) Mauna Loa N.E. Rift Zone, Hawaii
(6) Kilauea S.W. Rift Zone, Hawaii
(7) Kilauea East Rift Zone, Hawaii

The Kilauea Middle East Rift is located within the Kilauea East Rift Zone adjacent to lower east rift area now designated as the Kamaile Geothermal Resource Subzone and the upper east rift area known as Kahaualea.

B. Factors Used to Examine and Assess Potential Geothermal Resource Areas in Accordance with Act 296, SLH 1983, and the Assessment of the Kilauea Middle East Rift

Examination of the seven high temperature resource areas included in addition to potential for production of electrical energy the following factors:

- o prospects for utilization,
- o geologic hazards,
- o social impacts,
- o environmental impacts,
- o land use compatibility,
- o economic benefits, and
- o compatibility with land use zoning.

In accordance with Act 296, the assessment method is left to the discretion of the Board of Land and Natural Resources and may be based on currently available public information. Areas for potential designation as geothermal resource subzones must demonstrate an acceptable balance between the factors as set forth in Act 296, HRS.

The following summarizes the assessment of the factors listed in the Kilauea Upper East Rift Zone and in particular, the Kilauea Middle East Rift Zone.

1. Potential for Production

The consensus of the Geothermal Resource Assessment Technical Committee is that present day technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than 3 km to be feasible for production of electrical energy. (State Ex. 6, Circular C-103, G.S. No. 8/27/84-1)

Currently available geotechnical data indicates the presence of a geothermal resource along the entire Kilauea East Rift Zone and that there is a 90% chance probability that the temperature will be greater than 125°C at a depth of less than 3 km.

This finding is based on the extensive eruptive and intrusive activity along the entire length of the rift during the last millennium; an aeromagnetic anomaly associated with the rift showing temperatures in excess of 500°C at shallow depths; resistivity anomalies indicating shallow high temperature groundwater; the presence of high temperature shallow wells within and adjacent to the rift and a productive deep geothermal well.

The Technical Committee's evaluation further suggests a greater than 90% probability for a resource along the visible trace of the rift with a gradual decline in probability to the extent of the aeromagnetic anomaly.

Furthermore, intrepretation of aeromagnetic data suggests that a Curie temperature greater than 500° may be present at depths of 2-3 kilometers out from the limits of the 25% probability line originally drawn.

Also intrepretation of available geologic and gravity data suggests that the rift zone has migrated southward to its present location and is much broader in the northward direction than the present surface expression.

Therefore, the Kilauea middle east rift zone, located between the western boundary of the Kamaili geothermal resource subzone and the eastern boundary of Campbell Estate's land at Kahaualea is estimated at having a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km. (Note: The percent probability estimates the potential for high temperature and does not indicate whether a production reservoir exists nor the permeability or fluid characteristics of the area.)

The potential high temperature resource area of the Kilauea Middle East Rift is denoted by the 90% probability lines indicated on State Exhibit

No. 4. The area shown between the 90% and 25% probability lines represents decreasing geothermal resource potential.

2. Prospects for Utilization of the Geothermal Energy from the Area

The Big Island's demand for electricity is expected to be fairly stable. Considering existing electric generation capacity, the demand for geothermal electricity may be somewhat limited. However, two possible long-term scenarios would significantly increase the demand for geothermal electricity: (1) a deep water electrical transmission cable connecting the islands and/or (2) an energy intensive industry on the Big Island, e.g., manganese nodule processing. Either of these scenarios could increase demand by 250 MW. (State Ex. 14, G.S. No. 8/27/84-1)

3. Geologic Hazards that Potential Geothermal Projects Would Encounter

Potential geologic hazards include lava flows, pyroclastic fallout, ground cracks, earthquakes, subsidence, and tsunami. An analysis of Hawaiian geologic hazards and their possible effects on geothermal development is provided in Circular C-107, State Ex. 12, G.S. 8/27/84-1. It is supplemented by Circular C-114, State Exhibit 2, G.S. 9/26/85-5.

Lava Flows.

Kilauea is one of the world's most active volcanoes. Although eruptions have occurred more frequently in the upper rift zone, substantial volcanic risk is present along the entire Kilauea east rift zone.

The elevation of mildly sloping ridges north of the middle east rift zone axis may offer some protection from lava hazards. Heiheiahulu Crater in the southeast portion of the proposed GRS may be considered as an elevated geothermal site.

Within the past 24 years, four eruptions have covered parts of this proposed GRS. These flows have been concentrated in the western part of the proposed GRS. The 1961 flow covered 1% of the proposed GRS, the 1963 flow 2%, the 1977 flow 10% and the present Puu O'o flows 9%. The total percentage of land in the proposed GRS covered by these recent flows is about 22%. Puu O'o is presently providing the least resistive path to the surface for intrusive magma in the Kilauea east rift zone. It is unlikely that eruptions will occur downrift while the Puu O'o eruptions continue. However, it is not possible to accurately predict the precise time and place of future activity.

Decentralized facilities, strategic siting, and prudently constructed lava diversion platforms and barriers can be expected to mitigate the hazard risk from future flows. However, nothing can eliminate the substantial hazard from lava flows.

Pyroclastic Fallout.

Weight and depth of proclastic fallout is greatest around an eruptive vent. However, fallout can be appreciable 500 to 1000 m downwind of a vent. In 1959, a light pumice blanket extended 4000 m southwest from Kilauea Iki vent. In February 1985, high fountaining during the 30th phase of the Puu O'o eruption and strong NE Kona winds resulted in an appreciable amount of Pele's hair falling out over Hilo.

Protecting structures or machinery against damage by pyroclastic fallout may be achieved by enclosing those parts vulnerable to abrasion or contamination.

Ground Cracks.

Volcanic cracking is concentrated along the rift zone axis. A significant number of volcanic cracks are situated within the proposed Kilauea middle east rift GRS. Many cracks may be associated with a single volcanic event, as evidenced by the cracks formed during the 1961 eruption. Contingency planning should include the best available methods for sealing a well bore should a crack intercept a producing well.

Earthquakes.

Most earthquakes in Hawaii are volcanic, which are small in magnitude and cause little direct damage. Larger tectonic earthquakes tend to be situated in the saddle area between the calderas of Kilauea and Mauna Loa, and also in the Koae and Hilina fault systems--south of Kilauea's caldera. Recent earthquakes above magnitude 6 have occurred in the saddle area, e.g. the Kaoiki earthquake in November, 1983 (magnitude 6.7). The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana. Power plants should be constructed to withstand most island earthquakes.

Subsidence.

On the mainland, subsidence due to contraction of clay or sand formations may result from the withdrawal of geothermal fluids in those formations. In Hawaii, subsidence from geothermal fluid withdrawal is not likely to be a problem; since the islands are generally composed of dense, yet porous, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which may occur on or about active rift zones.

As a result of volcanic activity, small to large grabens may result with the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks, e.g. 1960 Kapoho graben. Subsidence may also be associated with tectonic earthquakes, collapsing lava tubes and pit craters.

Tsunamis.

Tsunami hazard is probably localized to a zone of land at most 2 km wide around the coast, and at elevations below about 75 feet. This will not be a hazard to developments in the proposed Kilauea middle east rift GRS as elevations are generally above 1400 feet.

4. Social Impacts

Social impacts related to geothermal development include health and noise concerns, impacts to lifestyle, culture and community setting, as well as aesthetic impacts.

Health Concerns.

The health concerns involve the possible effects of chemical, particulate and trace element emissions on the physical environment and nearby residents. Hydrogen sulfide (H_2S) is the most significant gas found in geothermal emissions, primarily because of its "rotten egg" smell at certain concentrations.

H_2S odor is detectable at 25 ppb. The State of Hawaii Department of Health has proposed a 25 ppb H_2S standard that geothermal developers will be required to meet. The California Departyment of Health Services' standard is 30 ppb and where this standard is enforced, no complaints of ill health due to H_2S have been noted.

The National Research Council Committee on Medical and Biological Effects of Environmental Pollutants has stated that exposure to low concentrations of H_2S has little or no importance to human health and represents nothing more than an unpleasant odor at very low concentrations. At higher concentrations, H_2S is an irritant gas, which causes local inflammation of the moist membranes of the eye and respiratory tract.

Studies of long-term exposure to low levels of H_2S in Rotorua, New Zealand, to both volcanic emissions and unabatted H_2S eimissions from a 200 MW geothermal electric plant reveal no evidence of health impairment. (Siegel, 1984)

Technology for abatement of hydrogen sulfide emissions to acceptable levels is available. The recommended Stretford system, the primary on-line abatement system, is capable of removing over 99% of the H_2S contained in the non-condensable gases emitted from a geothermal plant.

For control of noise and H_2S emissions during well flow testing, a caustic injection and rock muffler system can be utilized. A similar system is presently in use at the HGP-A well. Tests of this system at the HGP-A well have shown it to be 90-95 percent efficient in H_2S removal.

A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement-systems can be utilized in the event the plant is "down" for maintenance. If maintenance is required, the geothermal steam could be re-routed directly into the main plant condenser utilizing the primary abatement systems. If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scrubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal.

Noise Concerns.

The impact and intrusiveness of noise from geothermal development activities on the surrounding environs is dependent on the meteorological conditions; the intensity of the noise source; the measures taken to reduce the noise level; the sound propagation conditions existing between the source and listener; the ambient or background noise at the receptor; and the activity at the receptor area at the time of the noise event. (BLNR Findings of Fact, 2/25/83)

Although noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor which can be controlled and monitored.

The source of noise impact from the proposed geothermal resource subzone would arise from (a) construction of roads, pipelines, and buildings; (b) geothermal well-drilling and testing or venting; and (c) geothermal power plant operations.

During the initial phases of field development, persons in the immediate vicinity of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site.

Noise generated by construction activity will involve the use of standard construction equipment such as local bulldozers, trucks, and graders operating in the same manner, and over a limited time period as any other typical project. No unusual noise events of long duration are involved.

Within 100 feet of the drill rig, noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler.

The use of noise abatement procedures during venting, such as portable or in-place rock mufflers, can reduce noise levels from the drill site. Noise levels for proposed power plants are expected to be low and should result in slightly audible or inaudible levels at most receptor sites.

Power plant buildings and barriers can be designed to optimize the orientation and degree of closure to contain noises from the turbine, generator and transformers. Cooling towers have not proven to be dominant noise sources in geothermal plants. Taking all major noise sources into account, the continuous noise level of 75 dBA at 100 feet is considered readily achievable for power plants. (BLNR Findings of Fact, 2/25/83)

In May of 1981, the County of Hawaii Planning Department issued a set of "Geothermal Noise Level Guidelines" to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu, based on lower existing ambient noise levels for the Island of Hawaii.

These Noise Level Guidelines which have been attached to county permits controlling geothermal activities and include the following:

a. That a general noise level of 55 dBA during daytime and 45 dBA at night not be exceeded except as allowed under b. for the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period; and

c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation.

Geothermal development activities have been required to comply with the Geothermal Noise Level Guidelines of the Hawaii County Planning Department ("Guidelines"). The "Guidelines" specify that the "acceptable geothermal noise guidelines should be at a level which reasonably assumes that the Environmental Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met."

For example, the design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels (comparable to the sound of air conditioning at 20 feet). Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels (equivalent to light auto traffic) at the fence line of the project.

The BLNR has also similarly controlled noise associated with geothermal activities in areas zoned conservation. The BLNR Decision and Order of February 25, 1983 which allowed limited geothermal exploration on a portion of the Kahaualea land parcel in Puna, Hawaii included the following noise level restrictions:

> §9.3.5 - A general noise level of 55 dba during daytime and 45 dba at night shall not be exceeded except as allowed for impact noise. For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m. These general noise levels may be exceeded by a maximum of 10 dba for impact noise; however, in any event, the generally allowed noise level shall not be exceeded more than 10 percent of the time within any 20-minute period with the exception of venting operation in accordance with Chapter 183 of Title 13 of the Board's Administrative Rules and this order.

As any geothermal project progresses, noise propagation information will be obtained and will serve as guidance for the design of noise mitigation measures required of the power plants, particularly for power plants located close to noise sensitive residential and park areas.

The type of housing normally found near the vicinity of the proposed geothermal resource subzone, will result in noise reduction from outside to inside of at least 15 dB. Thus, an outside noise level of 45 dBA will reduce to an inside level of 30 dBA or less, which is less than the EPA's limiting standard of 32 dBA level to prevent sleep modification. (BLNR Findings of Fact, 2/15/83)

Lifestyle, Culture, and Community Setting

The lifestyle, culture and community setting or atmosphere of an area are very much inter-related and represent a major consideration in assessing the effects of any introduced changes.

The small magnitude of change in lifestyle and social interaction that may be brought about by new residents associated with geothermal development may be a small part of the lifestyle, culture and community and traffic changes already taking place in the Puna area as a result of the influx of new residents in recent years. (State Ex. 8, G.S. No. 8/27/84-1)

Prehistoric cultural activities and features such as foot trails, upland taro patches and planting areas, a pulu factory, and other sites have been reported in the area adjacent to the proposed subzone. As geothermal development occurs, each new increment of land area should be archaeologically surveyed by a qualified archaeologist after specific sites for development activity are determined and before land clearing begins. If archaeological sites are found, they should be described and assessed as to significance, and measures taken to ensure avoidance or mitigation of potential impacts from geothermal developments.

The practice of Hawaiian religion has included the belief and worship of the volcano goddess Pele. Some Hawaiian practitioners consider the lands adjacent to Kilauea Crater as sacred and the home of Pele. These practitioners consider the connections made with Pele in the past by their ancestors and today by themselves and their families, as essential to their daily life activities. To many native Hawaiians, Pele is regarded as aumakua and akua, and personal offerings have been made to Pele by religious practitioners for many years. (VCA Ex. 40, G.S. NO. 8/27/84-1) Some Hawaiians also identify themselves as the bloodline of Pele and believe that their existence and theology is threatened by the potential changes that may result from geothermal development. They also believe that geothermal development may forever extinguish or destroy essential parts of Hawaiian heritage, culture and religion.

Certain practitioners interpret the continuous eruptions at Puu O'o as signs of Pele's disapproval of geothermal activity and that Pele in her manifestation as steam cannot be sold for monetary gains. They are concerned about traditional Hawaiian beliefs regarding the use of steam, suggesting that Pele would be offended by geothermal development.

However, the recognition and use of geothermal energy has been recorded in the early history of the Hawaiian Islands by the Reverend William Ellis whose journal has been published in many editions. Explorers identified numerous fumaroles and thermal features on Kilauea and Mauna Loa volcanoes as early as 1825.

Early Hawaiians are recorded using steam emanating from fissures along the rift zone for cooking. William Ellis notes in his Journal published in 1825 that offerings to Pele consisting of hogs, dogs, fish and fruits were frequently made on heiau altars at Kilauea-Iki, and that these offerings were always cooked in the steaming chasms or the adjoining ground, least Pele reject them.

Ellis also notes that the ground in the vicinity of Kilauea, throughout the whole plain was so hot that those who came to the mountains to gather wood and to fell trees and hollow them for canoes "always cooked their own food, whether animal or vegetable, simply by wrapping it in fern leaves and burying it in the earth", a method quite similar to the Hawaiian imu.

At Kilauea on Hawaii, Handy and Handy, in their "Native Planters in Old Hawaii" describes how whole trunks of hapu'u pulu (fern trees) were thrown into steam fissures, covered with leaves, and when cooked, were split open and the starch core used as food for pigs.

The use of warm springs also was not unknown, since Ellis notes that at Kawaihae at the shore, warm springs provided a refreshing morning bath. Although the citation indicates a location removed from the Kilauea rift zone, the spring water is described as being "comfortably warm" and "probably impregnated with sulfur". He also notes medicinal qualities were ascribed to it by those who used it.

Aesthetics.

"The Puna Community Survey" by SMS Research Inc. reported that of the negative impacts perceived relating to the geothermal development, 5% felt that it "looks bad". The area respondents with the greatest percentage were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance.

In some areas with potential geothermal resource development, the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--however, consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping.

Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures, towers and plants with colors to blend in with the natural setting.

Drill rigs, including a platform, may reach to heights of approximately 150 feet. Rigs at various locations within a subzone may be temporarily visible above the tree line from view corridors into the development area.

It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the Kilauea east rift zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, some visible vapors are expected from the cooling towers.

Visibility of steam emissions from cooling towers will vary with output and atmospheric conditions; however, use of drift eliminators can reduce the size of the vapor plume. Silica deposition from surface disposal of geothermal brine can also create an aesthetic problem. Brine could be reinjected into deep rock strata. As an alternative, research may provide an aesthetic and environmentally acceptable brine treatment process.

In areas where development activity is close to National or State Parks, or recreation areas, estimates of potential visual impacts along sensitive view corridors should be made. Terrain analyses can be conducted to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen and to assess the visual impacts in relationship to size, distance, color, shape and other related factors.

Depending upon the terrain within and adjacent to a proposed project site, such an analysis may be required in environmental impact assessments for the development of specific sites within a geothermal resource subzone during the subsequent permitting process.

5. Environmental Impacts

Geothermal factors with a possible environmental effect include air emissions, liquid effluent, noise, visual aesthetics and physical disturbance during construction.

Air Emissions.

The most significant geothermal emission is hydrogen sulfide (H^2S). Chemical analyses on unabated, undispersed, geothermal steam at the Hawaii Geothermal Project - well A (HGP-A) indicate H_2S concentrations of 900 parts per million by weight. Other potential geothermal reservoirs in Hawaii may vary. H_2S abatement systems and normal air dispersion will drastically reduce the concentration of any emissions from a point source.

The State Department of Health (DOH) has proposed Ambient Air Quality Standards to control H_2S emissions from geothermal wells and power plants (Chapters 11-59 and 11-60 of the DOH Administrative Rules). The developer must obtain from the DOH an "authority to construct" prior to geothermal well or power plant construction and a "permit to operate" prior to connecting a well to a power plant (§11-60-23.1(d)). Geothermal wells and plants would have to show compliance with the State standards adopted. Current technology indicates that geothermal development activities can occur while meeting either the standards being considered or California standards which govern emissions from the largest geothermal development in the world.

A preliminary assessment of the levels of H_2S which can be expected from geothermal developments in Hawaii has been prepared by J. Morrow (1985). He concludes that under the most unfavorable atmospheric conditions a 25 MW plant with at least 98% H_2S removal efficiency appears capable of meeting the proposed state increment and ambient standard under normal and abnormal (steam stacking) operating conditions. A higher level of abatement efficiency by H_2S control systems may be necessary for larger plant sizes or when weather conditions work against normal dispersion of emissions.

The State DOH will set all standards necessary to protect the public health. Geothermal developers must demonstrate that these standards will be met both prior to construction and during operation. Technologies exist which have demonstrated abatement of H_2S emissions by approximately 99%.

Liquid Effluent.

Significant elements in geothermal brine include silica, chloride, and sodium. If not disposed of properly these elements have the potential to pollute potable water. Disposing of or minimizing the solids from silica deposition is a subject of concern whether the brine is discharged into a surface percolation pond or reinjected into deep rock strata. Some future projects at the Puna Geothermal Research Facility will investigate solutions to the problem of silica deposition. Aesthetic considerations may require brine disposal by reinjection. Geothermal development permits should indicate what method of brine disposal will be required.

The State DOH has established an Underground Injection Control program designed to protect the state's underground sources of drinking water (Chapter 11-23). These laws will regulate underground injections of geothermal fluids such that underground sources of drinking water are not polluted.

Groundwater monitoring and control can be required by development permits. The Board of Land and Natural Resources (BLNR) Decision and Order which allowed limited geothermal exploration at Kahaualea included the following sections: §9.2.6 requires water analyses during initial well drilling; §9.6.9 prohibits pollution of ocean and rivers by geothermal brine; and §9.6.10 states that no substances from geothermal wells shall be allowed to flow on the ground in such a manner as to create a health hazard.

Physical Disturbance During Construction - Effect on Flora and Fauna.

Direct physical disturbance by geothermal construction activities must be carefully planned to minimize damage to native forests which may be susceptible to invasion by exotic species along roadways or other cleared areas.

A detailed vegetation survey of Puna forests conducted by ~~S~~J.D. Jacobi in 1983, indicates that the highest quality native vegetation is located uprift and outside the proposed Kilauea middle east GRS; however, the western portion of the proposed GRS does contain some of this vegetation, as shown on ~~the~~ Figure 7 excerpted from State Exhibit 2, G.S. 9/26/85-C.

This vegetation consists of wet ohia forest with mixed native subcanopy trees with a tree fern native shrub understory.

Vegetation in the southwestern portion of the GRS is classified as closed canopy, wet ohia forest with mixed native subcanopy trees and a tree fern native shrub understory with some introduced shrubs and ferns. There are also small sections of ohia kukui forest present in the southwest section.

The northern portion of the proposed GRS include a large section of open canopy, wet ohia forest with mix native sub-canopy trees, and a tree fern native shrub understory with some introduced shrubs and ferns. The southeastern section contains wet pioneer ohia community. A significant portion of the proposed GRS is bare recent lava.

A recent flora and fauna survey, "Puna Geothermal Area Biotic Assessment", published in April 1985 by the University of Hawaii, Department of Botany, indicates that a number of plant species found within the east rift zone area are listed as Category 1 candidate species for listing as endangered by the U.S. Fish and Wildlife Service. Of the nineteen Category 1 species collected in the University's survey, only two are found within the proposed GRS, a medium sized tree, Bobea timonioides and Cynea tritomantha.

A Category 1 species is one for which the U.S. Fish and Wildlife Service has sufficient information to support the biological appropriateness of listing as endangered, but for which data still need to be collected concerning the environmental and economic impacts of listing the species and designating a critical habitat for it.

Bobea timonioides, also known as 'akakea, is found in Ohia forest types and was sighted at three locations in the proposed GRS, at one site in the designated Kapoho GRS, and at two sites along the lower rift zone outside the proposed GRS.

Cynea tritomantha var. tritomantha, known as 'aku'aku, was sighted in the northeast corner of the proposed GRS. It should be noted that the endemic fern, Adenophorus periens, was sighted mostly outside of the proposed GRS to the west and north.

The impact of geothermal development on these plant species can be avoided by careful facility siting and through the proper permit process.

Endangered birds sighted on the Kilauea middle east flank include the O'u, the I'o (Hawaiian Hawk), and the Nene (Hawaiian goose).

O'u sightings have been reported west and north of the proposed Kilauea middle east rift GRS and, as noted in the University's fauna survey, usually above the 3000-foot elevation. The authors of the Hawaii Forest Bird

Recovery Plan have recommended and the U.S. Fish and Wildlife Service has approved an essential habitat for the O'u which is believed to be necessary for the O'u to be restored to non-endangered status. The lower habitat boundary has been set at 2000-foot elevation, and as such includes only a small portion of the proposed GRS as shown on Figure 9 of Circular C-114. The proposed GRS should therefore have no adverse impact on the survival of the O'u. (State Ex. 2, G.S. No. 9/26/85-5)

The I'o is a roaming bird which has been sighted throughout the Puna area, over a wide range of ecosystem types including agricultural lands. Well sites and power plants will be sited so as to avoid known I'o nesting sites.

The primary range of the Nene is approximately 10 km to the west of the proposed Kilauea middle east rift GRS. Nene are not known to nest in the proposed GRS. Their present range is thought to be from 3800 to 8000 feet on the slopes of Mauna Loa.

6. Compatibility With Land Use Zoning

Under the provisions of Chapter 205-2 of the Hawaii Revised Statutes, Districting and Classification of Lands, there are four major land use districts in which all lands in the State are placed: (1) urban, (2) rural, (3) agricultural, and (4) conservation.

The great majority of the land within the proposed Kilauea middle east rift GRS is zoned Conservation-Protective. The extreme eastern and southeastern areas of this proposed GRS is zoned agricultural.

Act 296, SLH 1983 and as amended by Act 151, 1984, specifically states that "geothermal resource subzones may be designated within the urban, rural, agricultural, and conservation land use districts established under section 205-2. Only those areas designated as geothermal resource subzones may be utilized for geothermal development activities in addition to those uses permitted in each land use district under this chapter."

Methods for assessing the compatibility of geothermal development within a conservation district are left to the discretion of the Board and may be based on currently available public information. However, subzoning itself does not automatically permit any geothermal development or convey any rights to individuals beyond application for the required permits to conduct geothermal activities in any of these designated areas.

The authority of the Board to designate geothermal resource subzones shall be an exception to those provisions of Chapter 205 and of Section 26-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein. The provisions of this section shall not abrogate nor supersede the provisions of Chapters 182 and 183 (HRS).

If geothermal development activities are proposed within a conservation district, then, after receipt of a properly filed and completed application, the Board of Land and Natural Resources shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to Chapter 91 to determine whether, pursuant to Board regulations, a conservation district use permit shall be granted to authorize the geothermal development activities described in the application.

In granting a conservation district use permit (CDUA No. HA 3/2/82-1463) for geothermal exploration, the Board of Land and Natural Resources (BLNR) stated that "the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation lands involve multiple uses which range from absolute preservation to regulated uses...The range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restricted context." This balancing test may also be applied by the BLNR to conservation lands contained within the proposed Kilauea middle east rift GRS when subsequent permits are considered.

The counties control land use within agricultural districts. The County of Hawaii has already permitted the drilling of several geothermal wells on land zoned agricultural near the HGP-A geothermal facility. With regard to agricultural zoned land within the proposed Kilauea middle east rift GRS, the County will assess the propriety of geothermal development before granting their geothermal permits.

7. Economic Benefits

Development of geothermal resources would provide numerous job opportunities during the construction, maintenance, and operation of the roads, wells, and power generation facilities. The total number of employment opportunities will depend on specific development proposals. However, most jobs would be temporary construction jobs.

If we assume 25 project employees, direct wages may be about $560,000 annually, having a multiplier effect totalling an estimated $1.3 million. This would result in some impact on the state and county economy, but not a significant impact. A greater potential for permanent jobs for local residents may be provided by direct use applications of geothermal heat.

Various sources of public revenue may result from a geothermal facility, including property tax, fuel tax, general excise tax, corporate and personal income tax, and possibly royalty income. (State Ex. 9, G.S. No. 8/27/84-1)

Direct Use Applications

Direct use of geothermal heat should offer local residents many economic opportunities. The warm water effluent from a geothermal electric facility can provide an inexpensive source of process heat for various uses.

Some agricultural activities which can be supported by geothermal heat include: sugarcane processing, drying and dehydration of fruits and fish, fruit and juice canning, production of livestock feed from fodder, freeze drying of food and coffee, aquaculture and fishmeal production, refrigeration and ice making, soil sterilization, and fruit sterilization by dipping in hot water.

Industrial applications of direct geothermal heat may include extraction of potentially marketable minerals, such as silica or sulfur from geothermal fluids, production of cement building slabs, and production of liquid combustion fuels from biomass, e.g. bagasse or other agricultural by-products.

Other direct uses include hot geothermal mineral water spas which have proved to be of major commercial value in producing tourist revenue in Japan, Europe, U.S.S.R., and mainland United States, where millions visit these facilities annually. In places where fresh water is scarce, geothermal heat can be used to distill fresh water from saline water.

The transportability of geothermal heat is a significant limiting feature of direct use applications. Factors which influence transportability include initial and end-use temperatures, climate conditions, and whether steam or hot water is transporting the heat. Hot water can be transported much farther than steam. Depending on the direct use application, hot water can be transported about ten miles. Thus direct use facilities should be situated in close proximity to electric generation facilities.

The eastern and southeastern areas at the proposed Kilauea middle east rift GRS are presently zoned agricultural. The major portion of this proposed GRS is zoned conservation. It must be determined during subsequent permitting processes whether direct use applications of geothermal heat is an appropriate use in the agricultural and conservation areas of the proposed GRS (see section on compatibility). However, direct use activities are not legally restricted to geothermal resource subzones (Act 296 only restricts electrical uses to subzones).

If the benefits of direct use applications are to be available in several areas, then small decentralized geothermal facilities should be encouraged. Decentralized developments owned and operated by various developers may also promote competitive pricing for both electricity and process heat. With imaginative marketing, Big Island processed farm products can be sold world-wide. (State Ex. 2, G.S. No. 9/26/85-5)

V. CONCLUSION

The Division of Water and Land Development (DOWALD) of the Department of Land and Natural Resources, pursuant to the ~~a~~ Decision and Order rendered by the Board of Land and Natural Resources on December 28, 1984, conducted an assessment of the Kilauea middle east rift zone in and adjacent to the Puna Forest and Wao Kele 'O Puna Natural Area Reserve.

This land area, located between the western boundary of the Kamaili geothermal resource subzone and the eastern boundary of Kahaualea, was examined for resource potential and evaluations were made on geologic hazards, social, economic, and environmental impacts and compatibility of geothermal development. The potential geothermal resource area was evaluated on the basis of potential and real impacts which may occur within the identified area and in consideration of statutory state energy objectives and policies.

Based on the assessment factors above, the proposed Kilauea middle east rift GRS boundaries were determined as follows:

- Almost all of the land area contained in the proposed GRS is within the 90% probability area.
- GRS boundaries were drawn utilizing existing metes and bounds where possible, to clearly define subzone limits.
- The eastern boundary abuts the existing Kamaili GRS, straddling the 90% probability band and forming a contiguous land use designation.
- The southern boundary closely parallels the 90% probability ~~probably~~ line and is limited because the resource potential of areas to the south of 90% probability line is believed to diminish with distance from the rift zone. Also, permeability in areas south of the rift zone is expected to be low as a result of mineral deposition from salt water intrusion.

  Potential hazards from lava flows are greater south of the rift zone due to the southward sloping contour of the land.
- The western boundary was drawn assuming that Kahaualea is designated as a natural area reserve. The boundary provides a 2000 foot buffer between the GRS and Kahaualea to mitigate any possible effects on the substantial prime native forest and wildlife at Kahaualea.
- The northern GRS boundary as was drawn a reasonable distance north of the rift zone to provide for areas less susceptible to lava flow hazards. It is anticipated that power plants may be sited on locally elevated ground in these safer northern areas.

The potential geothermal resource area was assessed to have a greater than 90% probability of locating a high temperature resource. Potential impacts were identified and considerations given to mitigation measures and other requirements that may be imposed on a site-specific, case-by-case basis during subsequent State and County permitting.

Geologic hazards are present throughout the entire Kilauea east rift zone. Decentralization of facilities, strategic siting, and lava diversion platforms and barriers may mitigate damage from future lava flows. Development permits should require that all potential economic losses are to be assumed by developers.

The State Department of Health has proposed air quality standards and promulgated underground injection control regulations which will control geothermal emissions and effluent injections. Development permits should either prohibit or control surface water disposals. Geothermal noise levels have been regulated in exploration permits and such noise regulation is expected to continue throughout the development process.

Assuming the exchange of State and Campbell Estate lands is feasible and that Kahaualea is redesignated as a Natural Area Reserve, the proposed Kilauea middle east rift GRS will provide a 2000-foot buffer between the GRS and Kahaualea to mitigate any possible effects on the substantial prime native forest and wildlife at Kahaualea. Those scattered areas of prime native forest which are contained within the proposed GRS can be protected throughout the permitting process by requiring that development activities avoid these sensitive areas.

The State has established an objective of energy self-sufficiency and geothermal energy is viewed as a key to attaining this objective. Protection of the environment is also an area of high priority. The Division of Water and Land Development believes that both goals of geothermal development and environmental protection can be attained by permitting controlled development within the proposed Kilauea middle east rift GRS. This assessment has resulted in the identification of approximately 11,745 acres of the Kilauea middle east rift zone as a potential geothermal resource area and recommends that it be considered for designation as a geothermal resource subzone by the Board of Land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984.

VI. RECOMMENDATION

The Department of Land and Natural Resources recommends that the Board adopt the stated conclusion and grant the designation of the Kilauea Middle East Rift Zone as a geothermal subzone.

Dated: Honolulu, Hawaii, November 5, 1985.

MANABU TAGOMORI
Manager-Chief Engineer
Division of Water and Land Development
Department of Land & Natural Resources
State of Hawaii

BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone	)	G.S. No. 9/26/85-5

EXHIBIT LIST

Exhibit No.	Description
1	Proposal for Designating the Kilauea Middle East Rift Zone (Puna Forest Reserve) and the Kilauea Southwest Rift Zone (Pahala) as Geothermal Resource Subzones by the Board of Land and Natural Resources.
2	Proposed Kilauea Middle East Rift Geothermal Resource Subzone (Puna Forest Reserve), Island of Hawaii, Circular C-114. (BLNR D/O appended in C-114)
3	Puna Geothermal Area Biotic Assessment, Puna District, County of Hawaii, Final Report, April 1985.
4	Geothermal Resource Subzone map.
5	Geothermal Permits and Approvals.

DATED: Honolulu, Hawaii, November 5, 1985.

MANABU TAGOMORI
Manager-Chief Engineer
Division of Water and Land Development
Department of Land & Natural Resources
State of Hawaii

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing written testimony of Manabu Tagomori, Manager-Chief Engineer of the Division of Water and Land

Development, Department of Land and Natural Resources, State of Hawaii, was personally served on November 1, 1985, upon the following parties:

- Benjamin Matsubara and Stephanie Rezents, attorneys
  1717 Pacific Tower, 1001 Bishop Street, Honolulu, Hawaii 96813
  Representing: - Estate of James Campbell (intervenor-applicant)
  - True/Mid-Pacific Geothermal Venture (intervenor-applicant)

- Patricia O'Toole, Deputy Corporation Counsel
  25 Aupuni Street, Hilo, Hawaii 96720
  Representing: County of Hawaii; Planning Department

- Wendell Y. Y. Ing, attorney
  (Ken Kupchak, co-counsel)
  209 Kinoole Street, Room 8, Hilo, Hawaii 96720
  Representing:
  - Susan Carey (party)
  - Diane Ley (party)
  - Volcano Community Association (party)
  - Lehua Lopez (party)
  - Eva Lee (party)
  - Louis Whiteaker (party)
  - Chiu Leong (party)
  - Virginia B. MacDonald (party)
  - Debra Hopson (party)
  - Ann Markham (party)
  - Mike Markham (party)
  - Beverly MacCallum (party)
  - Matt Luera (party)
  - Hawaii Audubon Society (party)
  - Sierra Club, Hawaii Chapter (party)

In addition, the above Prehearing Statement was also served on November 1, 1985, via certified mail upon the following parties:

- Mae Evelyn Mull (party - representing herself)
  P.O. Box 275, Volcano, Hawaii 96785

- Frederick Warshauer (party - representing himself)
  P.O. Box 192, Volcano, Hawaii 96785

- Karl & Melissa Kirkendall (party)
  P.O. Box 428, Pahoa, Hawaii 96778

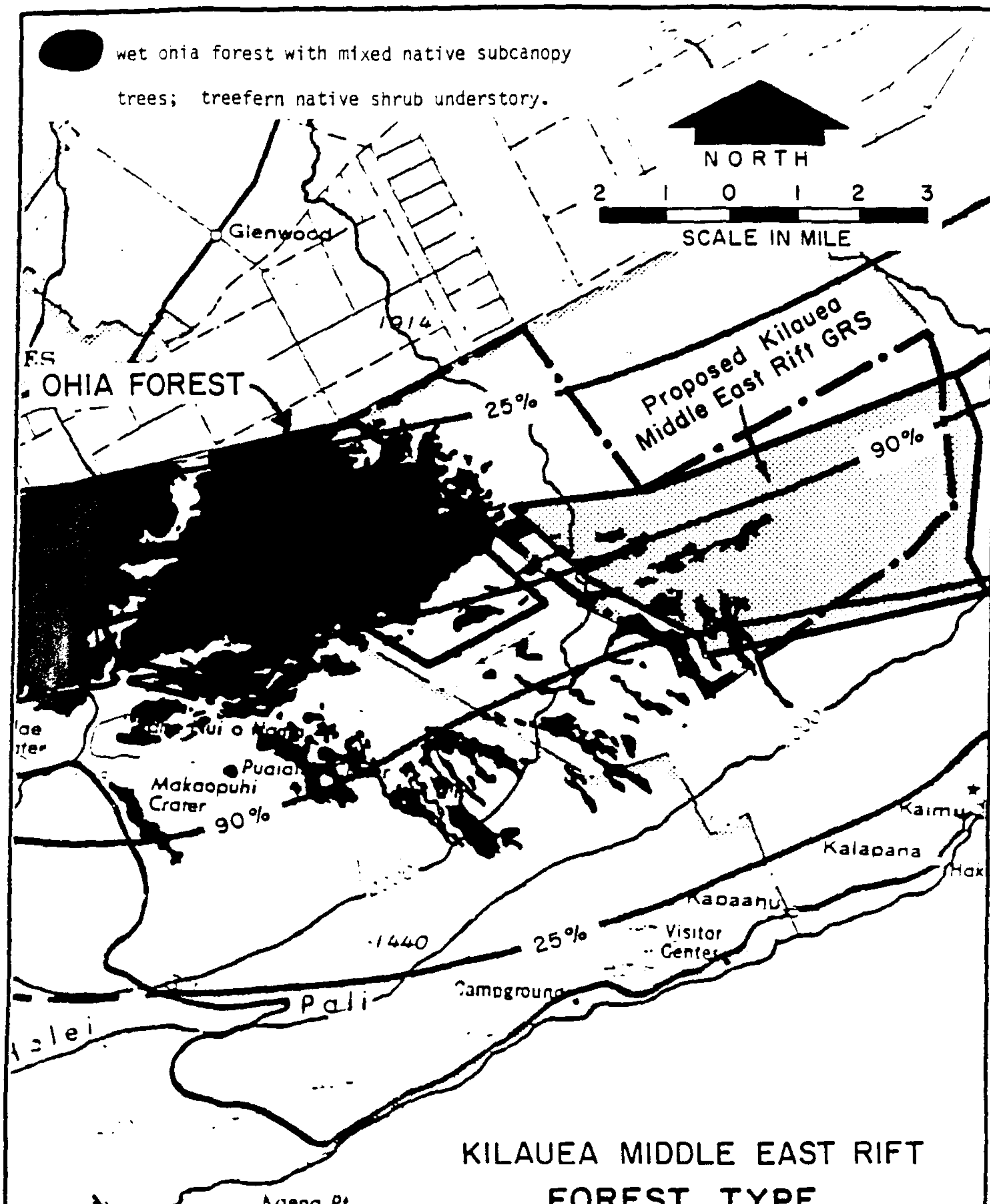
- John L. Perreira (party)
  212 Punahele St., Hilo, Hawaii 96720

- Palikapu Dedman (intervenor-applicant)
  P.O. Box 469, Naalehu, Hawaii 96722

- Emmett Aluli (Intervenor-applicant)
  P.O. Box H, Kaunakakai, Hawaii 96748

DATED: Honolulu, Hawaii, November 5, 1985.

MANABU TAGOMORI
Manager-Chief Engineer
Division of Water and Land Development
Department of Land & Natural Resources
State of Hawaii



Source: Vegetation Map of the Puna Study Area-Wet Habitat, Jacobi 1983.

KILAUEA MIDDLE EAST RIFT
FOREST TYPE
Island of Hawaii
Figure 7

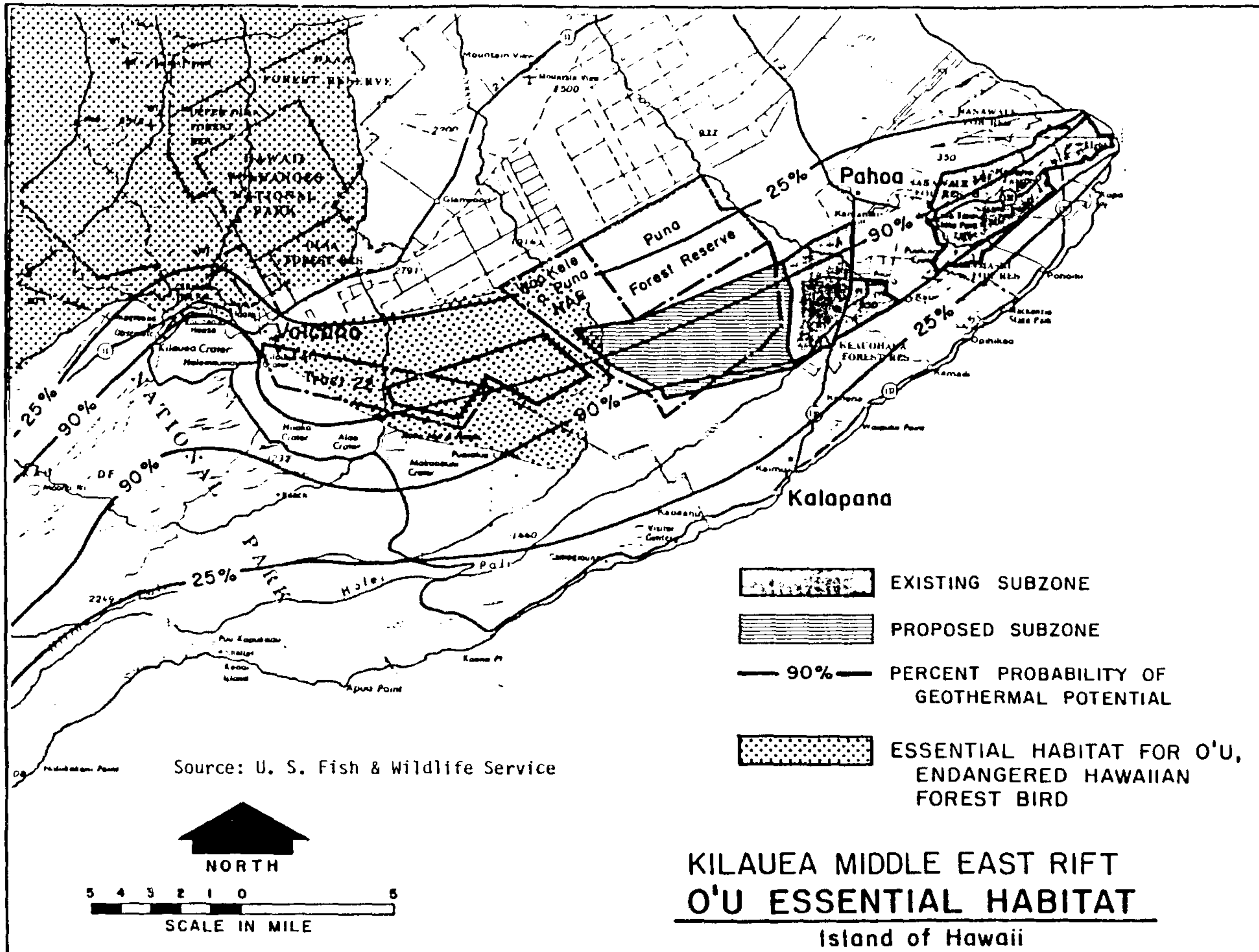

Pahoa
Kalapana
Volcano
Puna
Forest Reserve
Wao Kele o Puna NAR
Kilauea Crater
25%
90%
EXISTING SUBZONE
PROPOSED SUBZONE
90% PERCENT PROBABILITY OF GEOTHERMAL POTENTIAL
ESSENTIAL HABITAT FOR O'U, ENDANGERED HAWAIIAN FOREST BIRD
Source: U. S. Fish & Wildlife Service
NORTH
5 4 3 2 1 0 5
SCALE IN MILE
KILAUEA MIDDLE EAST RIFT
O'U ESSENTIAL HABITAT
Island of Hawaii

Figure 9

(To be made one and seven copies)

THE SENATE

TWELFTH LEGISLATURE 19 84

STATE OF HAWAII

S.B. NO. 2184-84
S.D. 1
H.D. 1
C.D. 1

ACT 151

A BILL FOR AN ACT

RECEIVED

84 JUN 7 P3:27

DEPT OF WATER & LAND DEVELOPMENT

RELATING TO GEOTHERMAL ENERGY.

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BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the rights of lessees holding geothermal mining leases issued by the state or geothermal developers holding exploratory and/or development permits from either the state or county government need to be clarified. The legislature finds that the respective roles of the state and county governments in connection with the control of geothermal development within geothermal resource subzones need to be clarified also. The purpose of this Act is to provide such further clarification.

SECTION 2. Section 205-5.1, Hawaii Revised Statutes, is amended to read as follows:

"[[]§205-5.1[]] Geothermal resource subzones. (a) Geothermal resource subzones may be designated within [each of] the urban, rural, agricultural and conservation land use districts established under section 205-2. Only those areas

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designated as geothermal resource subzones may be utilized for [the exploration, development, production, and distribution of electrical energy from geothermal sources,] geothermal development activities in addition to those uses permitted in each land use district under this chapter. Geothermal development activities may be permitted within urban, rural, agricultural, and conservation land use districts in accordance with this chapter. "Geothermal development activities" means the exploration, development or production of electrical energy from geothermal resources.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205-5.2[.]; except that the total area within an agricultural district which is the subject of a geothermal mining lease approved by the board of land and natural resources, any part or all of which area is the subject of a special use permit issued by the county for geothermal development activities, on or before the effective date of this Act is hereby designated as a geothermal resource subzone for the duration of the lease. The designation of geothermal resource subzones shall be governed exclusively by this section and section 205-5.2, except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein. The provisions of this section shall not abrogate nor supersede the provisions of chapters 182 and 183.

(c) The use of an area for [the exploration,] geothermal development[, production and/or distribution of electrical energy from geothermal sources] activities within a geothermal resource subzone shall be governed by the board within the conservation district and, except as herein provided, by [existing] state and county statutes, ordinances, and rules not inconsistent herewith within [the] agricultural, rural, and urban districts, except that no land use commission approval or special use permit procedures under section 205-6 shall be required for the use of such subzones. [The board and/or appropriate county agency shall, upon request, conduct a contested case hearing pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a preponderance of evidence.] In the absence of provisions in the county general plan and zoning ordinances specifically relating to the use and location of geothermal development activities in an agricultural, rural, or urban district, the appropriate county authority may issue a geothermal resource permit to allow geothermal development activities. "Appropriate county authority" means the county planning commission unless some other agency or body is designated by ordinance of the county council. Such uses as are permitted by county general plan and zoning ordinances, by the appropriate county authority, shall be deemed to be reasonable and to promote the effectiveness and objectives of this chapter. Chapters 177, 178, 182, 183, 205A, 226, 342, and 343 shall apply as appropriate. If provisions in the county general plan and zoning ordinances specifically relate to the use and location of geothermal development activities in an agricultural, rural, or urban district, the provisions shall require the appropriate county authority to conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91, on any application for a geothermal resource permit to determine whether the use is in conformity with the criteria specified in section 205-5.1(e) for granting geothermal resource permits.

(d) If geothermal development activities are proposed within a conservation district, then, after receipt of a properly filed and completed application, the board of land and natural resources shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether, pursuant to board regulations, a conservation district use permit shall be granted to authorize the geothermal development activities described in the application.

(e) If geothermal development activities are proposed within agricultural, rural, or urban districts and such proposed activities are not permitted uses pursuant to county general plan and zoning ordinances, then after receipt of a properly filed and completed application, the appropriate county authority shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether a geothermal resource permit shall be granted to authorize the geothermal development activities described in the application. The appropriate county authority shall grant a geothermal resource permit if it finds that applicant has demonstrated by a preponderance of the evidence that:

(1) The desired uses would not have unreasonable adverse health, environmental, or socio-economic effects on residents or surrounding property; and

(2) The desired uses would not unreasonably burden public agencies to provide roads and streets, sewers, water, drainage, school improvements, and police and fire protection; and

(3) That there are reasonable measures available to mitigate the unreasonable adverse effects or burdens referred to above.

Unless there is a mutual agreement to extend, a decision shall be made on the application by the appropriate county authority within six months of the date a complete application was filed; provided that if a contested case hearing is held, the final permit decision shall be made within nine months of the date a complete application was filed."

SECTION 3. Notwithstanding the provisions of section 205-5.2, Hawaii Revised Statutes, regarding county-by-county assessment of areas with geothermal potential, the board of land and natural resources shall separately conduct an assessment of the area described on maps attached to the board of land and natural resources decision and order, dated February 25, 1983, which was the subject of a conservation district use permit. The assessment shall be in accordance with all provisions of Act 296, Session Laws of Hawaii 1983, regarding the procedures and standards for designation of an area as a geothermal resource subzone. The board of land and natural resources shall make its determination regarding the designation of all or any portion of the abovementioned area, as a geothermal resource subzone, on or before December 31, 1984.

SECTION 4. If any provision of this Act or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 5. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 6. This Act shall take effect upon its approval.

Approved by the Governor on MAY 25 1984

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(To be made one and seven copies)

THE SENATE

......TWELFTH.... LEGISLATURE, 19 83

STATE OF HAWAII

ACT 296

S.B. NO. 903 S.D. 1 H.D. 2 C.D. 1

A BILL FOR AN ACT

RELATING TO GEOTHERMAL ENERGY.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

SECTION 2. Section 182-4, Hawaii Revised Statutes, is amended to read as follows:

"§182-4 <u>Mining leases on state lands.</u> <u>(a)</u> If any mineral is discovered or known to exist on state lands, any interested person may notify the board of land and natural resources of his desire to apply for a mining lease. The notice shall be accompanied by a fee of $100 together with a description of the land desired to be leased and the minerals involved and such information and maps as the board by regulation may prescribe. As soon as practicable thereafter, the board shall cause a notice to be published in a newspaper of general circulation in the county where the lands are located, at least once in each of three successive weeks, setting forth the description of the land, and the minerals desired to be leased. The board may hold the public auction of the mining lease within six months from the date of the first publication of notice or such further time as may be reasonably necessary. Whether or not the state land sought to be auctioned is then being utilized or put to some productive use, the board, after due notice of public hearing to all parties in interest, within six weeks from the date of the first publication of notice or such further time as may be reasonably necessary, shall determine whether the proposed mining operation or the existing or reasonably foreseeable future use of the land would be of greater benefit to the State. If the board determines that the existing or reasonably foreseeable future use would be of greater benefit to the State than the proposed mining use of the land, it shall disapprove the application for a mining lease of the land without putting the land to auction.

The board shall determine the area to be offered for lease and, after due notice of public hearing to all parties in interest, may modify the boundaries of the land areas. At least thirty days prior to the holding of any public auction, the board shall cause a notice to be published in a newspaper of general circulation in the State at least once in each of three successive weeks, setting forth the description of the land, the minerals to be leased, and the time and place of the auction. Bidders at the public auction may be required to bid on the amount of annual rental to be paid for the term of the mining lease based on an upset price fixed by the board, a royalty based on the gross proceeds or net profits, cash bonus, or any combination or other basis and under such terms and conditions as may be set by the board.

(b) Any provisions to the contrary notwithstanding, if the person who discovers the mineral discovers it as a result of exploration permitted under section 182-6, and if that person bids at the public auction on the mining lease for the right to mine the discovered mineral and is unsuccessful in obtaining such lease, that person shall be reimbursed by the person submitting the highest bid at public auction for the direct or indirect costs incurred in the exploration of the land, excluding salaries, attorney fee's and legal expenses. The department shall have the authority to review and approve all expenses and costs that may be reimbursed."

SECTION 3. Chapter 205, Hawaii Revised Statutes, is amended by adding new sections to be appropriately designated and to read as follows:

"§205- Geothermal Resource Subzones. (a) Geothermal resource subzones may be designated within each of the land use districts established under section 205-2. Only those areas designated as geothermal resource subzones may be utilized for the exploration, development, production, and distribution of electrical energy from geothermal sources, in addition to those uses permitted in each land district under this chapter.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205- . The designation of geothermal resource subzones shall be governed exclusively by this section and section 205- , except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein.

(c) The use of an area for the exploration, development, production and/or distribution of electrical energy from geothermal sources within a geothermal resource subzone shall be governed by the board within the conservation district and by existing state and county statutes, ordinances, and rules within the agricultural, rural, and urban districts, except that no land use commission approval shall be required for the use of subzones. The board and/or appropriate county agency shall, upon request, conduct a contested case hearing pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a preponderance of evidence. Chapters 183, 205A, 226, and 343 shall apply as appropriate.

§205- Designation of areas as Geothermal Resource Subzones. (a) Beginning in 1983, the board of land and natural resources shall conduct a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal resource subzones. This assessment shall be revised or updated at the discretion of the board, but at least once each five years beginning in 1988. Any property owner or person with an interest in real property wishing to have an area designated as a geothermal resource subzone may submit a petition for a geothermal resource subzone designation in the form and manner established by rules and regulations adopted by the board. An environmental impact statement as defined under chapter 343 shall not be required for the assessment of areas under this section.

(b) The board's assessment of each potential geothermal resource subzone area shall examine factors to include, but not be limited to:

(1) The area's potential for the production of geothermal energy;

(2) The prospects for the utilization of geothermal energy in the area;

(3) The geologic hazards that potential geothermal projects would encounter;

(4) Social and environmental impacts;

(5) The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

(6) The potential economic benefits to be derived from geothermal development and potential related industries; and

(7) The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board shall consider, if applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226.

(c) Methods for assessing the factors in subsection (b) shall be left to the discretion of the board and may be based on currently available public information.

(d) After the board has completed a county-by-county assessment of all areas with geothermal potential or after any subsequent update or review, the board shall compare all areas showing geothermal potential within each county, and shall propose areas for potential designation as geothermal resource subzones based upon a preliminary finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Once such a proposal is made, the board shall conduct public hearings pursuant to this subsection, notwithstanding any contrary provision related to public hearing procedures.

(1) Hearings shall be held at locations which are in close proximity to those areas proposed for designation. A public notice of hearing, including a description of the proposed areas, an invitation for public comment, and a statement of the date, time, and place where persons may be heard shall be published and mailed no less than twenty days before the hearing. The notice shall be published on three separate days in a newspaper of general circulation state-wide and in the county in which the hearing is to be held. Copies of the notice shall be mailed to the department of planning and economic development, and the

<u>planning commission and planning department of the county in which the proposed areas are located.</u>

<u>(2) The hearing shall be held before the board, and the authority to conduct hearings shall not be delegated to any agent or representative of the board. All persons and agencies shall be afforded the opportunity to submit data, views, and arguments either orally or in writing. The department of planning and economic development and the county planning department shall be permitted to appear at every hearing and make recommendations concerning each proposal by the board.</u>

<u>(3) At the close of the hearing, the board may designate areas as geothermal resource subzones or announce the date on which it will render its decision. The board may designate areas as a geothermal resource subzones only upon finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Upon request, the board shall issue a concise statement</u>

of its findings and the principal reasons for its decision to designate a particular area.

(e) The designation of any geothermal resource subzone may be withdrawn by the board of land and natural resources after proceedings conducted pursuant to the provisions of chapter 91. The board shall withdraw a designation only upon finding by a preponderence of the evidence that the area is no longer suited for designation, provided that the designation shall not be withdrawn for areas in which active exploration, development, production or distribution of electrical energy from geothermal sources is taking place.

(f) This Act shall not apply to any active exploration, development or production of electrical energy from geothermal sources taking place on the effective date of the Act, provided that any expansion of such activities shall be carried out in compliance with its provisions."

SECTION 4. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 5. If any provision of this Act, or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 6. This Act shall take effect upon its approval.

Approved by the Governor on JUN 14 1983

AGENDA
FOR THE MEETING OF THE
BOARD OF LAND AND NATURAL RESOURCES

DATE: NOVEMBER 16, 1984
TIME: 9:00 A. M.
PLACE: KALANIMOKU BUILDING
RM. 132, BOARD ROOM
1151 PUNCHBOWL STREET
HONOLULU, HAWAII

A. MINUTES

SEPTEMBER 14, 1984

D. DIVISION OF WATER AND LAND DEVELOPMENT

1. NATIONAL FLOOD INSURANCE PROGRAM
2. SOIL AND WATER CONSERVATION DISTRICT DIRECTORS
3. PERMISSION TO ENGAGE THE SERVICES OF A CONSTRUCTION MANAGEMENT CONSULTANT FOR JOB NO. 2-HW-21, RENOVATION OF UPPER HAMAKUA DITCH AND CONSTRUCTION OF ACCESS ROAD, WAIMEA IRRIGATION SYSTEM, SOUTH KOHALA, HAWAII
4. DESIGNATION OF GEOTHERMAL RESOURCE SUBZONE, KAPOHO SECTION, LOWER KILAUEA RIFT ZONE, ISLAND OF HAWAII
5. DESIGNATION OF GEOTHERMAL RESOURCE SUBZONE, KAMAILI SECTION, LOWER KILAUEA EAST RIFT ZONE, ISLAND OF HAWAII
6. DESIGNATION OF GEOTHERMAL RESOURCE SUBZONE, HALEAKALA SOUTHWEST RIFT ZONE, ISLAND OF MAUI

E. DIVISION OF STATE PARKS

1. PERMISSION TO ADVERTISE FOR BIDS, JOB NO. 24-KP-22, ASPHALT CONCRETE PAVING, KOKEE STATE PARK, WAIMEA, KAUAI
2. REQUEST TO USE AINA MOANA STATE RECREATION AREA FOR FUND RAISING FUN RUN

F. DIVISION OF LAND MANAGEMENT

1. TRANSMITTAL OF DOCUMENTS FOR BOARD CONSIDERATION:

(A) BONIFACE KEKAHUNA, SR. APPLICATION FOR R.P., HONOPOU, HAMAKUALOA, MAKAWAO, MAUI

(B) HAWAII WING, CIVIL AIR PATROL, REQUEST FOR CONSENT TO AGREEMENT WITH C&C OF HONOLULU FOR USE OF PORTION OF G.L. NO. S-4487, WAIANAE, OAHU

(C) LARRY KOMATA REQUEST FOR CONSENT TO ASSIGN, G.L. NO. S-4334 COVERING LOT 10, PANAEWA FARM LOTS, 2ND SERIES, WAIAKEA, SO. HILO, HAWAII

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development
Honolulu, Hawaii

November 16, 1984

Chairperson and Members
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Gentlemen:

Designation of Geothermal Resource Subzone
Kapoho Section, Lower Kilauea East Rift Zone, Island of Hawaii

Pursuant to Act 296, Session Laws of Hawaii 1983, and Act 151, Session Laws of Hawaii 1984, the Department of Land and Natural Resources initiated staff work in early 1983 for the designation of geothermal resource subzones in the State of Hawaii by the Board of Land and Natural Resources. The objective of establishing subzones is to allow geothermal resource exploration, development, and production of electrical energy to take place in areas having low impacts to social, economic, environmental, geological hazards, compatibility with surrounding land uses and other related aspects of interest to the communities, the County, and the State.

The Department's staff with assistance from a geothermal resource technical committee and a consultant completed the following work tasks: assessment of available information on geothermal resources in Hawaii; promulgated the Administrative Rules on geothermal resource subzones; assessment of geothermal resources in the State of Hawaii on a county-by-county basis; conducted impact analysis on social, economic, environmental, geologic hazards, compatibility to existing and planned land uses, and the relationship to other State and County programs.

The staff conducted several community meetings to discuss those areas identified as having potential geothermal resources to produce electrical energy and the various components relating to impacts to the communities, County and the State. The staff presented the information to the Board and subsequently a "Proposal for Designating Geothermal Resource Subzones" was issued by the Board in July 1984.

The Board proposed that the Kapoho Section of the Lower Kilauea East Rift Zone, Island of Hawaii, covering an area of 5211 acres be a candidate for designation as a geothermal resource subzone. Public hearings on the proposal was conducted by the Board on September 11-12, 1984. The majority of testimonies received were in support of the Board's proposal and are summarized as follows:

- Increased energy self-sufficiency for the State of Hawaii and less dependence on foreign fuel imports.
- The creation of new jobs and added revenue to the State.
- Development of additional industries which could utilize geothermal by-products and energy.
- Recommendation that the Board move with great urgency in the designation of geothermal resource subzones. Eliminating delays will help control costs and expedite the development of feasible alternate energy and improve the economic climate of the State.

ITEM D-4

The testimonies submitted that were in opposition to the proposal are summarized below:

- Potential health hazards and adverse effects resulting from geothermal emissions, such as air, noise and water catchment pollution.
- Potential destruction of native forests and impacts on endangered flora and fauna.
- Incompatibility with existing land uses and community setting including scenic and aesthetic qualities.

Upon review of all submitted testimonies, the staff concluded that all environmental concerns related to the designation of geothermal resource subzones can be readily mitigated through proper planning and current technology. The use of abatement systems and compliance with existing and proposed Department of Health Standards can insure public safety. In addition, appropriate mitigation measures can be required during subsequent State and County permitting to be imposed on a case-by-case basis to eliminate or minimize potential adverse effects.

RECOMMENDATION:

That the Board designate the Kapoho Section of the Lower Kilauea East Rift Zone, Island of Hawaii, containing 5211 acres of land as a geothermal resource subzone. The boundaries of the subzone are shown on the attached Exhibit "A" and further identified by Tax Map Key in Exhibit "B".

Respectfully submitted,

Robert T. Chuck

ROBERT T. CHUCK
Manager-Chief Engineer

Attach.

APPROVED FOR SUBMITTAL:

S. Ono

SUSUMU ONO, Chairperson

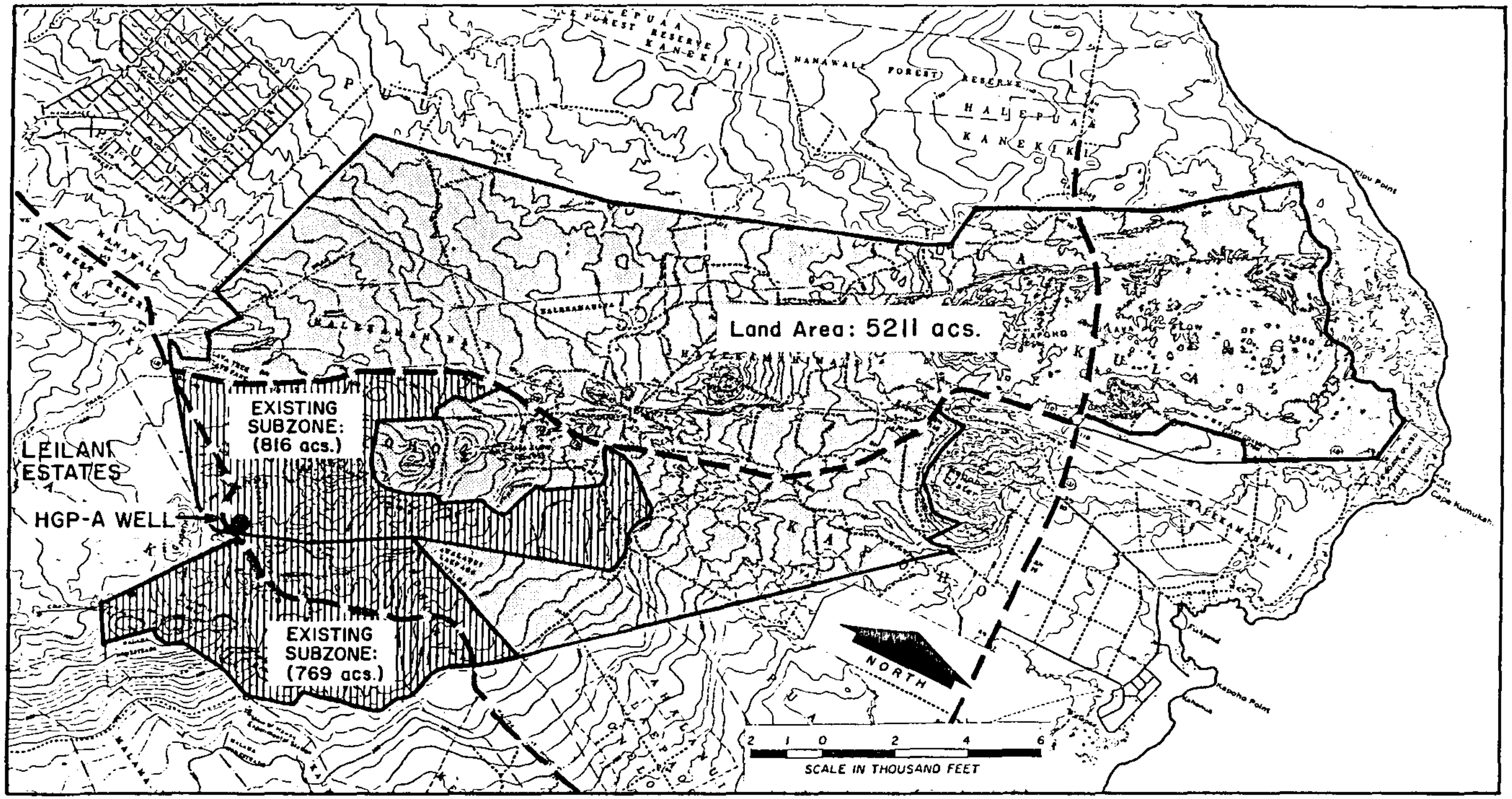


EXHIBIT A

PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT
(KAPOHO SECTION)
Island of Hawaii

KILAUEA LOWER EAST RIFT
(Kapoho Section)
Island of Hawaii

TMK	Owner/Lessor Lessee	Area	
Portion of 1-4-01-10	Kapoho Land & Dev. Co. Ltd.	*258.69	ac.
1-4-01-13	Kapoho Land & Dev. Co. Ltd.	3.21	ac.
Portion of 1-4-01-17	Tokyu Land Dev. Hawaii Inc.	*801.24	ac.
Portion of 1-4-01-21	Murphy, John E., etal	*15.95	ac.
Portion of 1-4-01-26	Reid, Randolph K./Laurie B.	*1.01	ac.
Portion of 1-4-01-27	Torigoe, Takeo/Kimiko S. Reid, Randolph K./Laurie B.	*2.41	ac.
Portion of 1-4-01-28	Imaino, Paul M.	*0.69	ac.
Portion of 1-4-01-31	Shinde, Tsurue	*5.44	ac.
Portion of 1-4-01-32	Shinde, Tsurue	*5.35	ac.
Portion of 1-4-01-33	Klingenstein, Clara L. R.C. Roberts and Co. Kenny, Duane	*17.51	ac.
Portion of 1-4-01-40	Klingstein, Clara L.	*8.47	ac.
Portion of 1-4-01-46	Rierson, Ronald V.	*3.54	ac.
Portion of 1-4-01-55	Plumeria Farms & Ent. Inc.	*9.39	ac.
Portion of 1-4-01-56	Yamada, Ryuichi/A., etal Teasdale, Raymond	*3.58	ac.
1-4-01-64	Tokyu Land Dev. Hawaii Inc.	40.10	ac.
1-4-01-65	Tokyu Land Dev. Hawaii Inc.	40.03	ac.
1-4-01-66	Tokyu Land Dev. Hawaii Inc.	40.01	ac.
1-4-01-67	Tokyu Land Dev. Hawaii Inc.	40.00	ac.
1-4-01-68	Tokyu Land Dev. Hawaii Inc.	40.02	ac.
1-4-01-69	Tokyu Land Dev. Hawaii Inc.	40.02	ac.
1-4-01-71	Tokyu Land Dev. Hawaii Inc.	40.00	ac.

EXHIBIT B

TMK	Owner/Lessor Lessee	Area	
1-4-01-72	Tokyu Land Dev. Hawaii Inc.	81.85	ac.
1-4-01-73	Tokyu Land Dev. Hawaii Inc.	40.01	ac.
1-4-01-74	Tokyu Land Dev. Hawaii Inc.	80.00	ac.
1-4-01-75	Tokyu Land Dev. Hawaii Inc.	80.15	ac.
1-4-01-76	Tokyu Land Dev. Hawaii Inc.	40.01	ac.
1-4-01-77	Tokyu Land Dev. Hawaii Inc.	40.01	ac.
1-4-01-78	Tokyu Land Dev. Hawaii Inc.	40.00	ac.
1-4-01-79	Tokyu Land Dev. Hawaii Inc.	40.24	ac.
Portion of 1-4-01-81	Reid, Randolph K./Laurie B.	*1.17	ac.
1-4-02-2	Kapoho Land & Dev. Co. Ltd.	1089.30	ac.
1-4-02-18	Kapoho Land & Dev. Co. Ltd.	454.89	ac.
1-4-02-32	Kapoho Land & Dev. Co. Ltd.	444.50	ac.
Portion of 1-4-02-34	Richfield of Hawaii Inc., etal	*323.56	ac.
Portion of 1-4-02-37	B. P. Bishop Tr. Est. Ikeda, Leighton	*36.00	ac.
Portion of 1-4-02-67	Kealoha, James/Miulan Y. Pa O Puna Farm Ltd.	*19.77	ac.
Portion of 1-4-02-68	Kealoha, James/Miulan Y. Pa O Puna Farm Ltd.	*66.86	ac.
1-4-05-1	Swain, Rose P.K., etal	30.91	ac.
1-4-05-2	Young, Tim Hu/Elizabeth	2.47	ac.
1-4-05-4	Elderts, William Sr. Estate Elderts, Herman K.	1.00	ac.
Portion of 1-4-05-18	Worswick, John W./Lorna M.	*1.35	ac.
1-4-05-22	Kenoi, Nellie Hookano McBride, Grace	2.00	ac.
1-4-05-23	Aiona, Keai Kualapai Aiona, Aka Agnes K.	1.00	ac.

TMK	Owner/Lessor Lessee	Area	
1-4-05-25	Mathews, Margaret A.F.	1.00	ac.
1-4-05-29	Chong, Wing K., etal	15.00	ac.
1-4-05-31	Akoni, Margaret B., etal Akoni, Margaret B.	.73	ac.
1-4-06-1	Akahori, Ted S.	.40	ac.
1-4-06-2	Makino, Eugene/Kazue Makino, Kazue	.28	ac.
1-4-06-8	State of Hawaii	.17	ac.
1-4-06-9	Tanaka, Chiyoki	.36	ac.
1-4-06-10	Nakahara, Hisako T., etal Yukitomo, Masako	.82	ac.
1-4-06-11	Soga, Manubu/Tamiko Soga, Manabu	.94	ac.
1-4-06-12	Masuda, Takeo	1.05	ac.
1-4-06-13	Shimizu, Miki, etal J.T. Shimizu, Kaoru	.51	ac.
1-4-06-15	State of Hawaii	0.00083	ac.
1-4-06-16	State of Hawaii	0.38	ac.
1-4-07-2	Matsumoto, Hisayo, etal	.037	ac.
1-4-07-3	Uyeda, Masao/Yukiko K.	.042	ac.
1-4-07-4	Herbst, Arthur G./Jeanne D. Israel, Aaron L.	.65	ac.
1-4-07-5	Sakaguchi, Joji/Misako	0.51	ac.
1-4-07-6	Herbst, Arthur G., etal Pommerenk, Gregory C., etal	.99	ac.
1-4-07-7	Ching, Reginald K.Y.	.019	ac.
1-4-08-1	(1) Tanioka, Isami Trs. (2) Tanioka, Isami Trs.	.07 .19	ac. ac.
1-4-08-2	Kawaguchi, Harold Y. Mildred	0.86	ac.

TMK	Owner/Lessor Lessee	Area	
1-4-08-3	Shimasaki, Yasu, etal, J.T.	0.48	ac.
1-4-08-4	Soga, Kuniji Mr./Mrs.	.94	ac.
1-4-08-5	Takeguchi, Yutaka	1.11	ac.
1-4-09-2	Mansfield, Charles F.	.85	ac.
1-4-09-3	Seiji, Kawate, etal J.T.	0.67	ac.
1-4-09-4	Fukumoto, Kijiro/T.	0.39	ac.
1-4-09-5	Chun, Stanley/Katherine	0.39	ac.
1-4-09-6	Uyeki, Kametaro/Hajime Uyeki, Henry K.	0.44	ac.
1-4-09-7	Nakamura, Haruo/Sumiko	0.33	ac.
1-4-09-8	Seki, Yoshikazu/Utako	0.45	ac.
1-4-09-9	State of Hawaii	0.12	ac.
1-4-12-1	Niiya, Kazuo/May M.	5.45	ac.
1-4-12-2	Kapoho Land & Dev. Co., Ltd.	2.59	ac.
1-4-12-3	Hoffman, Philip	1.53	ac.
1-4-12-4	Willhite, Jean B. Trustee	2.04	ac.
1-4-12-5	Willhite, Jean B. Trustee	11.85	ac.
1-4-12-6	DeLuz, David S. Markham, Steven R., etal	24.43	ac.
1-4-12-7	Kapoho Land & Dev. Co. Ltd.	2.04	ac.
1-4-13-1	Nuha, Susmu/Yoshiko Nuha, Sam	5.27	ac.
1-4-13-2	Krueger, William E.	7.34	ac.
1-4-13-3	Lae Lae Joint Venture	15.30	ac.
1-4-13-4	Huelskamp, Richard F., etal	0.09	ac.
1-4-13-5	Huelskamp, Richard F./Carol D.	4.09	ac.
1-4-13-6	Huelskamp, Richard F., etal	9.75	ac.

TMK	Owner/Lessor Lessee	Area	
1-4-13-7	Kapoho Land & Dev. Co. Ltd.	2.08	ac.
1-4-14-1	Santo Nobuchika/Sachiyo	0.44	ac.
1-4-14-2	Higa, Robert Y./Sayoko N.	5.96	ac.
1-4-14-3	Higa, Robert Y./Sayoko N.	5.55	ac.
1-4-14-4	Kamei, Masami	.49	ac.
1-4-14-5	Kamei, Umeki, etal Jacinto, Manuel	10.58	ac.
1-4-14-6	Kamei, Umeki, etal Jacinto, Manuel	3.66	ac.
1-4-14-7	Dote, James Tadashi	2.19	ac.
1-4-14-8	Dote, James Tadashi	2.94	ac.
1-4-14-9	Iwata, Isamu/E.	5.19	ac.
1-4-14-10	Iwata, Raymond H.	7.39	ac.
1-4-14-11	Kapoho Land & Dev. Co. Ltd.	2.22	ac.
1-4-14-12	Kapoho Land & Dev. Co. Ltd.	.70	ac.
1-4-14-13	Tanioka, Isami Trustee Tanioka, I. Transp. & Farm Inc.	13.61	ac.
1-4-14-14	Miyose, Myles/Morris	1.45	ac.
1-4-14-15	Kapoho Land & Dev. Co. Ltd.	.06	ac.
1-4-15-1	Bishop Trust Co. Ltd. Trs.	7.21	ac.
1-4-15-2	Santo, Tsuyoshi	3.92	ac.
1-4-15-3	Sakaguchi, Joji/Misako	19.51	ac.
1-4-15-4	Santo, Tsukasa/Masayo	11.63	ac.
1-4-15-5	Dote, James Tadashi	14.41	ac.
1-4-15-6	Kapoho Land & Dev. Co. Ltd.	1.85	ac.
1-4-15-7	Kapoho Land & Dev. Co. Ltd.	.56	ac.
1-4-15-8	Yoza, Allan M.	3.02	ac.

TMK	Owner/Lessor Lessee	Area	
1-4-15-9	Santo, Tsuyoshi	.73	ac.
1-4-15-10	Kapoho Land & Dev. Co. Ltd.	.34	ac.
1-4-16-1	Duff, Ruth M.	17.74	ac.
1-4-16-2	Kapoho Land & Dev. Co. Ltd.	5.49	ac.
1-4-16-3	Kapoho Land & Dev. Co. Ltd.	6.01	ac.
1-4-16-4	Kapoho Land & Dev. Co. Ltd.	.24	ac.
1-4-16-5	Hiwa Hiwa A Joint Venture	4.43	ac.
1-4-16-6	Maus, River R., etal Hicks, Douglas J.	8.16	ac.
1-4-16-7	Kapoho Land & Dev. Co. Ltd.	6.02	ac.
1-4-16-8	Kapoho Land & Dev. Co. Ltd.	1.33	ac.
1-4-16-9	Honda, Melvin T./Kayleen K. Thermal Power Co., etal	9.70	ac.
1-4-17-10	Fukumoto, Kijiro/Teru Thermal Power Co., etal	9.45	ac.
1-4-16-11	Namba, Kenneth H. Thermal Power Co.	10.85	ac.
1-4-16-12	Kapoho Land & Dev. Co. Ltd.	2.08	ac.
1-4-16-13	Kobayashi, Yoshimi/Kazuko Thermal Power Co., etal	2.00	ac.
1-4-17-1	Terry Schoneberg Inc. French, Thomas. B.	5.70	ac.
1-4-17-2	Frink, William E., etal	4.84	ac.
1-4-17-3	Kapoho Land & Dev. Co. Ltd. Duff, Ruth M.	32.10	ac.
1-4-17-4	Kiffe, J.W., etal K.G.C. A Joint Venture	5.71	ac.
1-4-17-5	Conboy, Elmer/Marigold Sarhanis, Andrew J.	4.33	ac.
1-4-17-6	Iwata, Raymond H./J.R.	4.91	ac.

TMK	Owner/Lessor Lessee	Area
1-4-17-7	Altman, Dale/Margaret	5.33 ac.
1-4-17-8	Iwata, Akira, etal Thermal Power Co., etal	4.96 ac.
1-4-17-9	Promised Land Corp. Wengerd T./Lyman L.	4.86 ac.
1-4-17-10	Pommerenk, Albert/T.G.	4.32 ac.
1-4-17-11	Duff, William Lee Waiau, Gilbert, etal	7.46 ac.
1-4-17-12	Iwata, Akira, etal Thermal Power Co., etal	1.37 ac.
1-4-17-13	Kapoho Land & Dev. Co. Ltd.	4.27 ac.
1-4-18-1	Iwata, Isamu/E.H. Thermal Power Co., etal	3.44 ac.
1-4-18-2	Iwata, Isamu/Edith H. Thermal Power Co., etal	13.49 ac.
1-4-18-3	Uyeda, Tsuneo, etal Uyeda, Edward T.	3.01 ac.
1-4-18-4	Uyeda, Tsuneo, etal Uyeda, Edward T.	2.09 ac.
1-4-18-5	Kobayashi, Hideo/Yoshimi Thermal Power Co., etal	5.50 ac.
1-4-18-6	Schaumburg, Dale P., etal	10.29 ac.
1-4-18-7	Miyatake, Shiryo/Sadame Thermal Power Co., etal	7.81 ac.
1-4-18-8	Miyatake, Shiryo/Sadame Thermal Power Co., etal	4.37 ac.
1-4-18-9	Iwata, Akira, etal Thermal Power Co., etal	4.77 ac.
1-4-18-10	Iwata, Akira, etal Thermal Power Co., etal	3.46 ac.
1-4-18-11	White, Clayton, etal	13.62 ac.

TMK	Owner/Lessor Lessee	Area	
1-4-18-12	Kapoho Land & Dev. Co. Ltd.	1.91	ac.
1-4-18-13	Iwata, Isamu/Edith H. Thermal Power Co., etal	1.11	ac.
1-4-18-14	Kapoho Land & Dev. Co. Ltd.	1.28	ac.
1-4-19-1	Higashi, Masakichi/Kimie Thermal Power Co., etal	8.39	ac.
1-4-19-2	Kawate, Robert M., etal Thermal Power Co., etal Kawate, Randy/Karen	19.89	ac.
1-4-19-3	Kobayashi, Hideo/Yoshimi Thermal Power Co., etal	15.87	ac.
1-4-19-4	Uyeda, Tsuneyo, etal Matsuura, Clarence, etal	11.66	ac.
1-4-19-5	Yamada, Katsuyu	4.45	ac.
1-4-19-6	Ching, Reginald K.Y.	8.10	ac.
1-4-19-7	Ching, Reginald K.Y.	1.55	ac.
1-4-19-8	Landt, Mark R.	8.80	ac.
1-4-19-9	Ikeda, Mervin K./Elinor N.	1.70	ac.
1-4-19-10	Kapoho Land & Dev. Co. Ltd.	.39	ac.
1-4-19-11	A Small Piece of Haw. Ltd. Bryant, Nancy M.	.22	ac.
1-4-19-12	Ching, Reginald K.Y.	.21	ac.
1-4-19-13	Kapoho Land & Dev. Co. Ltd.	.04	ac.
1-4-20-1	Kamei, Umeko, etal	8.40	ac.
1-4-20-2	Marthaller, C.R./F.J.	1.03	ac.
1-4-20-3	Wood, Nathan C./Janet C.	3.00	ac.
1-4-20-4	Weeks, Donald D./Junko	2.90	ac.
1-4-20-5	Shimasaki, Yutaka Cohen, Rudolf A./Joyce	3.59	ac.

TMK	Owner/Lessor Lessee	Area	
1-4-20-6	Kapoho Land & Dev. Co. Ltd.	8.37	ac.
1-4-20-7	Kuwahara, Akisuke, etal Thermal Power Co. Ltd. Tanoue Tado/Yuriko, etal	17.50	ac.
1-4-20-8	Higa, Robert Y./Sayoko N. Thermal Power Co., etal	6.23	ac.
1-4-20-9	Kapoho Land & Dev. Co. Ltd.	.50	ac.
1-4-20-10	Kapoho Land & Dev. Co. Ltd.	.36	ac.
1-4-20-11	Kapoho Land & Dev. Co. Ltd.	.69	ac.
1-4-20-12	Wood, Nathan C./Janet C. Mimzey, Carolyn	2.99	ac.
1-4-21-1	Kakugawa, Matsue	13.64	ac.
1-4-21-2	Kapoho Land & Dev. Co. Ltd.	1.62	ac.
1-4-21-3	Ikeda, Shinji/Janet	.56	ac.
1-4-21-4	Ikeda, Shinji/Janet	6.90	ac.
1-4-21-5	Uyeda, Tsuneyo	3.87	ac.
1-4-21-6	Nakashima, Lorilei, etal	2.49	ac.
1-4-21-7	Herbst, Arthur G./Jane F.	9.80	ac.
1-4-21-8	Kapoho Land & Dev. Co. Ltd.	.79	ac.
1-4-22-1	Kukino, Hisashi/Tomiye	9.41	ac.
1-4-22-2	Nakanishi, Roy M./Dorothy P.	10.71	ac.
1-4-22-3	Pacific Properties Ltd.	6.95	ac.
1-4-22-4	Ito, Philip J./Carole Nalani Farms Inc.	.94	ac.
1-4-22-5	Ito, Philip J./Carole Nalani Farms Inc.	4.60	ac.
1-4-22-6	Kuwahara, Akisuke/D.	5.34	ac.
1-4-22-7	Richardson, Lynn P., etal	1.20	ac.

TMK	Owner/Lessor Lessee	Area
1-4-22-8	Richardson, Lynn P., etal	.86 ac.
1-4-22-9	Kuwahara, Akisuke/D.M.	5.62 ac.
1-4-22-10	Kuwahara, Akisuke/D.M.	1.49 ac.
1-4-22-11	Kelly, Gladys C., etal Kelly, James W.N.	1.00 ac.
1-4-22-12	Kelly, Gladys C., etal Kelly James W.N.	4.78 ac.
1-4-22-13	Oshita, Hatsue	3.76 ac.
1-4-22-14	Oshita, Hatsue	4.03 ac.
1-4-22-15	Kapoho Land & Dev. Co., Ltd.	2.12 ac.
1-4-22-16	Klein, Henry F./Rita T.	1.17 ac.
1-4-23-1	Johnson, Alice M., etal	13.70 ac.
1-4-23-2	Kawabata, Masakazu Kawabata, Osamu	16.58 ac.
1-4-23-3	Kawabata, Masakazu Kawabata, Osamu	17.73 ac.
1-4-23-4	Goshigaisha Ito Building	7.14 ac.
1-4-23-5	Dote, James Tadashi Chun, Stanley	11.65 ac.
1-4-23-6	Kapoho Land & Dev. Co. Ltd. Lange, Leon/C.P. Perry, Delan/Jennifer	15.00 ac.
1-4-23-7	Kapoho Land & Dev. Co. Ltd.	2.18 ac.
1-4-24-1	Chong, Clayton E., etal	3.67 ac.
1-4-24-2	R & J Steel Inc.	3.31 ac.
1-4-24-3	H & S Enterprises Inc.	7.78 ac.
1-4-24-4	H & S Enterprises Inc.	3.39 ac.
1-4-24-5	R & J Steel Inc.	3.13 ac.
1-4-24-6	Namba, Kenneth H., etal	1.09 ac.

TMK	Owner/Lessor Lessee	Area	
1-4-24-7	Chong, Clayton E., etal	8.21	ac.
1-4-24-10	Kapoho Land & Dev. Co. Ltd.	2.13	ac.
1-4-24-11	Kapoho Land & Dev. Co., Ltd.	2.15	ac.
Portion of 1-4-78-1	Tokioka, Lionel Y., etal, Trs.	*0.14	ac.
Portion of 1-4-78-2	Nani United Corporation Ltd.	*2.75	ac.
Portion of 1-4-78-3	Nani United Corporation Ltd.	*2.48	ac.
Portion of 1-4-78-4	Spercel, Anne	*2.40	ac.
Portion of 1-4-78-5	Chung, Kenneth K.H./Hyesil	*2.50	ac.
Portion of 1-4-78-6	Isbell, Donald D./V. Trust	*2.50	ac.
Portion of 1-4-78-7	Lau, Eric S.	*2.40	ac.
Portion of 1-4-78-8	James, Mary M.	*1.51	ac.
Portion of 1-4-78-9	Natl. Securities & Invest. Buck, Thomas A.	*0.43	ac.
		*5,211.00	

*Approximate acreage.

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development
Honolulu, Hawaii

November 16, 1984

Chairperson and Members
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Gentlemen:

Designation of Geothermal Resource Subzone
Kamaili Section, Lower Kilauea East Rift Zone, Island of Hawaii

Pursuant to Act 296, Session Laws of Hawaii 1983, and Act 151, Session Laws of Hawaii 1984, the Department of Land and Natural Resources initiated staff work in early 1983 for the designation of geothermal resource subzones in the State of Hawaii by the Board of Land and Natural Resources. The objective of establishing subzones is to allow geothermal resource exploration, development, and production of electrical energy to take place in areas having low impacts to social, economic, environmental, geological hazards, compatibility with surrounding land uses and other related aspects of interest to the communities, the County, and the State.

The Department's staff with assistance from a geothermal resource technical committee and a consultant completed the following work tasks: assessment of available information on geothermal resources in Hawaii; promulgated the Administrative Rules on geothermal resource subzones; assessment of geothermal resources in the State of Hawaii on a county-by-county basis; conducted impact analysis on social, economic, environmental, geologic hazards, compatibility to existing and planned land uses, and the relationship to other State and County programs.

The staff conducted several community meetings to discuss those areas identified as having potential geothermal resources to produce electrical energy and the various components relating to impacts to the communities, County and the State. The staff presented the information to the Board and subsequently a "Proposal for Designating Geothermal Resource Subzones" was issued by the Board in July 1984.

The Board proposed that the Kamaili Section of the Lower Kilauea East Rift Zone, Island of Hawaii, covering an area of 5405 acres be a candidate for designation as a geothermal resource subzone. Public hearings on the proposal was conducted by the Board on September 11-12, 1984. The majority of testimonies received were in support of the Board's proposal and are summarized as follows:

- Increased energy self-sufficiency for the State of Hawaii and less dependence on foreign fuel imports.
- The creation of new jobs and added revenue to the State.
- Development of additional industries which could utilize geothermal by-products and energy.
- Recommendation that the Board move with great urgency in the designation of geothermal resource subzones. Eliminating delays will help control costs and expedite the development of feasible alternate energy and improve the economic climate of the State.

ITEM D-5

The testimonies submitted that were in opposition to the proposal are summarized below:

- Potential health hazards and adverse effects resulting from geothermal emissions, such as air, noise and water catchment pollution.
- Potential destruction of native forests and impacts on endangered flora and fauna.
- Incompatibility with existing land uses and community setting including scenic and aesthetic qualities.

Upon review of all submitted testimonies, the staff concluded that all environmental concerns related to the designation of geothermal resource subzones can be readily mitigated through proper planning and current technology. The use of abatement systems and compliance with existing and proposed Department of Health Standards can insure public safety. In addition, appropriate mitigation measures can be required during subsequent State and County permitting to be imposed on a case-by-case basis to eliminate or minimize potential adverse effects. A major land owner recommended that the proposed area be expanded to include the area covered by an existing State mining lease. This subzone expansion will be studied for possible inclusion as a geothermal subzone area in early 1985.

RECOMMENDATION:

That the Board designate the Kamaili Section of the Lower Kilauea East Rift Zone, Island of Hawaii, containing 5405 acres of land as a geothermal resource subzone. The boundaries of the subzone are shown on the attached Exhibit "A" and further identified by Tax Map Key in Exhibit "B".

Respectfully submitted,

Robert T. Chuck

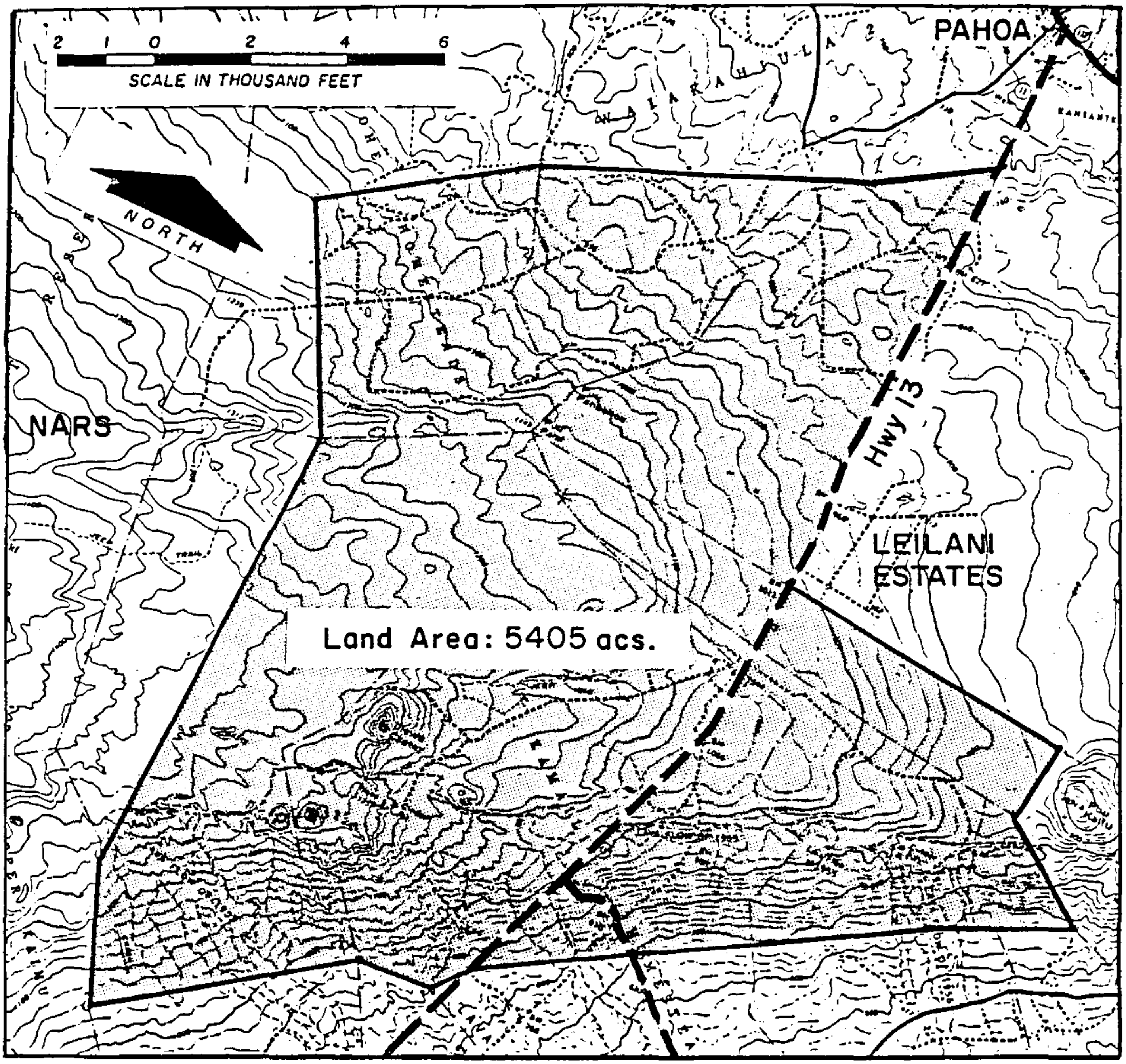
ROBERT T. CHUCK
Manager-Chief Engineer

Attach.

APPROVED FOR SUBMITTAL

S. Ono

SUSUMU ONO, Chairperson



PROPOSED GEOTHERMAL RESOURCES SUBZONE

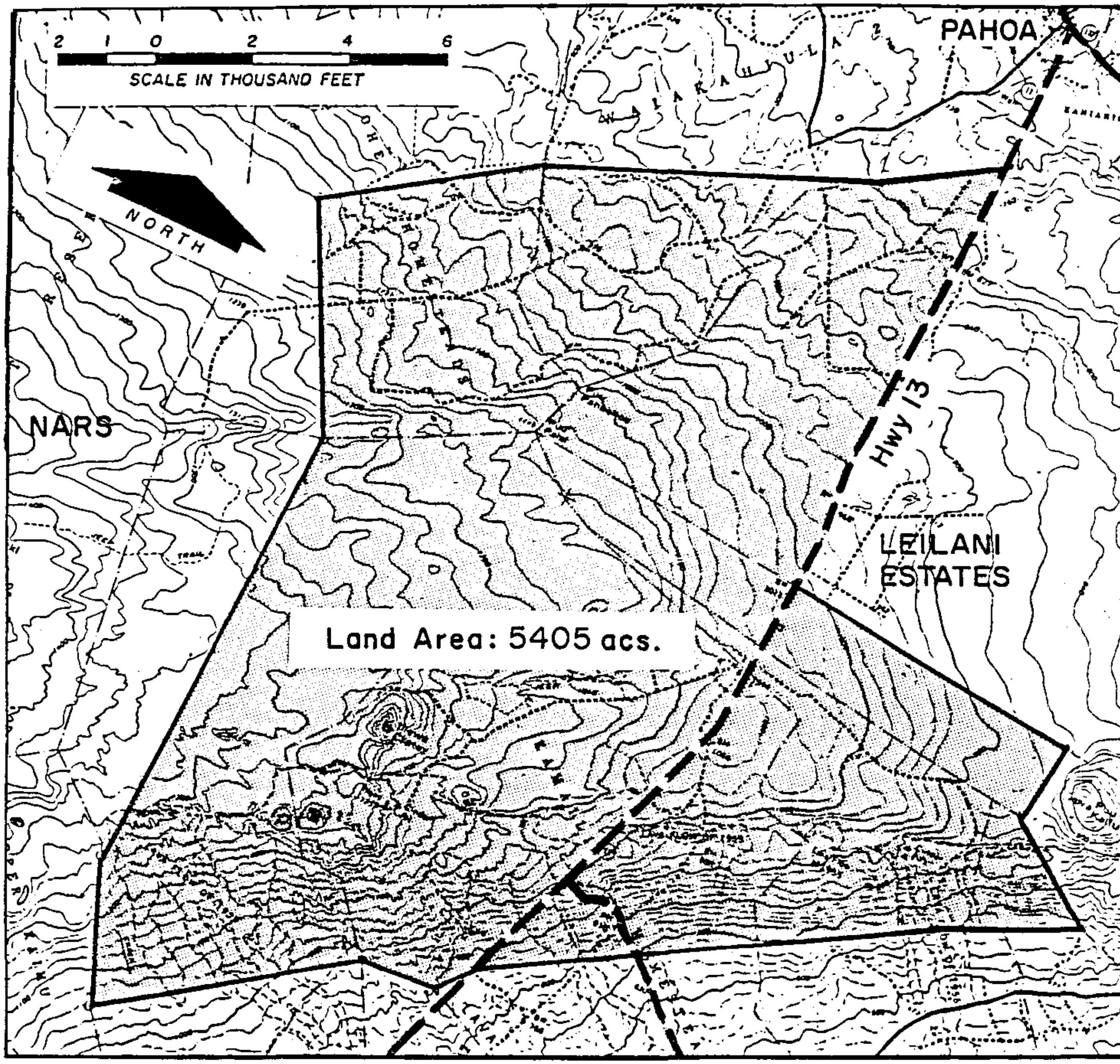
KILAUEA LOWER EAST RIFT (KAMAILI SECTION)

Island of Hawaii

EXHIBIT A

TMK	Owner/Lessor Lessee	Area (acre)
1-5-01-28	Knapp, Thomas P. etal	19.01
1-5-01-29	Knapp, Thomas P. etal	.76
1-5-01-30	Knapp, Thomas P. etal	1.31
1-5-01-31	Sato, Hiroo/Satsuki Puna Sugar Co., Ltd.	35.86
1-5-01-32	Sanekane, Toshimi Toshimi, Sanekane	2.63
1-5-01-33	Tanaka, Shigeyo etal	14.45
1-5-01-34	Sato, Hayami etal Sato, Hiroo	10.50
1-5-01-35	Kelly Terry M./Mary etal	4.65
1-5-01-36	Wallach, Keith L.	4.65
1-5-01-37	Holzgrove, Charles/Ponira T.	4.65
1-5-01-38	Reyburn, Steve/Cherokee	4.65
1-5-01-39	Stout, Dennis/Marthann	4.65
1-5-01-40	Kaohe Ranch Assoc. Siracusa, Rene etal	35.78
1-5-01-49	Eguchi, Eugene M. Trust etal	11.45
1-5-01-50	Nishimura, Albert G/F	10.00
Portion of 1-5-01-55	Oishi, Stanley Y./Hiroko	32.27*
	Total	5,405.00*

*Approximate acreage.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT (KAMAILI SECTION)

Island of Hawaii

EXHIBIT A

KILAUEA LOWER EAST RIFT
(Kamaili Section)
Island of Hawaii

TMK	Owner/Lessor Lessee	Area (acre)
Portion of 1-2-10-1	State of Hawaii	1447.50*
Portion of 1-3-01-1	Puna Sugar Co., Ltd.	76.56*
1-3-01-2	Puna Sugar Co., Ltd.	12.20
1-3-01-3	Kamelamela, Joseph K. etal	25.70
1-3-01-4	Kamelamela, Joseph K. etal	6.60
1-3-01-7	Puna Sugar Co., Ltd.	559.81
1-3-01-8	Thompson, Cleo L. etal	20.10
1-3-01-9	A&E Enterprises, Ltd.	21.32
1-3-01-10	Pahoa 15	27.44
Portion of 1-3-01-16	Puna Sugar Co., Ltd.	66.60*
1-3-01-17	Elderts, Kahikina etal Kauwes Land & Res. Dev., Inc.	164.58
1-3-01-18	Edwards, Richard G. etal Edwards, Helen E.	7.94
1-3-01-19	Ranne-Keeney-Scroggins	5.29
1-3-01-20	Baker, Ronald C.	1.34
1-3-01-21	Puna Sugar Co., Ltd.	47.00
1-3-01-22	Bishop, B.P. Trust Est. Trs. B.P. Bishop Estate	27.78
1-3-01-23	Bishop, B.P. Trust Est. Trs. B.P. Bishop Estate	237.40
1-3-01-24	Ashida, Harold T./Clara	49.60
Portion of 1-3-01-25	Jungers, Elizabeth Miller Derek Russell etal	19.08*
Portion of 1-3-01-26	Lee, Curtis W. etal Lee, Yilman	7.00*
1-3-01-31	Daiichi Seiko of HI	81.17
1-3-01-32	McCandless, Paula E. etal Paula E. McCandless	.44
1-3-01-35	Great Hawn Financial Corp.	48.83
1-3-01-36	Green, James Simpson Green, William F.	.06

EXHIBIT B

TMK	Owner/Lessor Lessee	Area (acre)
1-3-01-42	Lee Construction, Inc.	9.42
1-3-01-43	Takagi, Henry H/S	1.32
1-3-01-47	Daiichi Seiko of HI	3.06
1-3-01-48	Daiichi Seiko of HI	.19
1-3-01-49	Edwards, Richard G. etal Edwards, Helen E.	16.55
1-3-01-51	McCandles, Paula E. etal McCandles, Paula E.	.32
1-3-01-52	Elderts, Kahikina H. Mrs. Dec'd John Kaheiki	1.35
1-3-01-53	Puna Sugar Co., Ltd.	16.70
1-3-01-54	Puna Sugar Co., Ltd.	2.80
1-3-01-55	Puna Sugar Co., Ltd.	18.54
1-3-01-58	Bishop, B.P. Tr. Est. Trs. B.P. Bishop Estate	33.50
Portion of 1-3-01-60	Yamanaka, Vern M/Mary C. Pedersen, Keith G.E. etal	12.00*
Portion of 1-3-01-61	Yamanaka, Vern M./Mary C. Hull Gronroos	3.50*
1-3-01-62	Thompson, Cleo L. etal	24.57
1-3-01-63	A&E Enterprises, Ltd.	26.25
1-3-01-64	A&E Enterprises, Ltd.	23.61
1-3-01-65	A&E Enterprises, Ltd.	25.05
1-3-01-66	A&E Enterprises, Ltd.	23.96
1-3-01-67	A&E Enterprises, Ltd.	23.06
1-3-01-68	A&E Enterprises, Ltd.	23.35
1-3-01-69	A&E Enterprises, Ltd.	24.01
1-3-09-1	Bishop, B.P. Tr. Est. Trs. B.P. Bishop Estate	206.17
1-3-09-2	Bishop, B.P. Tr. Est. Goodness, William N. Trs. B.P. Bishop Estate	157.72
1-3-09-3	Puna Sugar Co., Ltd.	405.19
1-3-09-8	Bishop, B.P. Tr. Est. HBK Enterprises, Ltd.	5.17
1-3-09-10	Bishop, B.P. Est. Trs.	23.26
1-3-09-11	Water Comm. County Hawaii	.26

TMK	Owner/Lessor Lessee	Area (acre)
Portion of 1-3-09-14	Puna Sugar Co., Ltd. Trust Hawan Trust Co., Ltd.	342.54*
Portion of 1-3-09-16	Puna Sugar Co., Ltd.	30.27*
Portion of 1-3-10-7	Phillips, Ken C. Enter., Inc. Compton, Randy	0.40*
Portion of 1-3-10-11	Robinson, Albert G. Twin River Del Bonita PO	0.80*
Portion of 1-3-10-12	Pomeroy, James E/Gail Ann	0.96*
1-3-10-13	Robinson, Albert G. Twin River Del Bonita PO	3.99
1-3-10-14	Water Resources Int'l Inc. Bridgens, R.G./Miller, B.	3.98
1-3-10-15	Cutler, Allen etal	3.87
1-3-10-16	Kuna Basil	4.70
Portion of 1-3-10-17	Gutierrez, Fernando	2.82*
Portion of 1-5-10-3	Roman Catholic Mission Bishop Trust Co., Ltd.	396.58*
1-5-01-4	Harte, Roy S. etal Harte-Hural	24.74
1-5-01-5	Yamaguchi, Kazuo/Kiyoichi Kazuo Yamaguchi	46.60
1-5-01-6	Kuwahara, Alan A. etal	42.39
1-5-01-7	Taguchi, Paul J. etal Puna Sugar Co., Ltd.	45.20
1-5-01-8	Yamaguchi, Takeo	45.60
1-5-01-9	Kaohe Ranch Assoc. Farmer, Robert N.	35.79
1-5-01-13	Oishi, Toru/Faye, F.	33.15
1-5-01-14	Knapp, Thomas P. etal Knapp, Gideon/Sherri	12.64
1-5-01-15	Knapp, Thomas P. etal	2.17
Portion of 1-5-01-16	Oishi, Stanley/Hiroko	4.06*
Portion of 1-5-01-23	Yamada, Emma Trust Puna Sugar Co., Ltd.	10.56*
Portion of 1-5-01-24	Yamada, Emma Trust Puna Sugar Co., Ltd.	10.75*
1-5-01-27	Knapp, Thomas P. etal	31.32

TMK	Owner/Lessor Lessee	Area (acre)
1-5-01-28	Knapp, Thomas P. etal	19.01
1-5-01-29	Knapp, Thomas P. etal	.76
1-5-01-30	Knapp, Thomas P. etal	1.31
1-5-01-31	Sato, Hiroo/Satsuki Puna Sugar Co., Ltd.	35.86
1-5-01-32	Sanekane, Toshimi Toshimi, Sanekane	2.63
1-5-01-33	Tanaka, Shigeyo etal	14.45
1-5-01-34	Sato, Hayami etal Sato, Hiroo	10.50
1-5-01-35	Kelly Terry M./Mary etal	4.65
1-5-01-36	Wallach, Keith L.	4.65
1-5-01-37	Holzgrove, Charles/Ponira T.	4.65
1-5-01-38	Reyburn, Steve/Cherokee	4.65
1-5-01-39	Stout, Dennis/Marthann	4.65
1-5-01-40	Kaohe Ranch Assoc. Siracusa, Rene etal	35.78
1-5-01-49	Eguchi, Eugene M. Trust etal	11.45
1-5-01-50	Nishimura, Albert G/F	10.00
Portion of 1-5-01-55	Oishi, Stanley Y./Hiroko	32.27*
	Total	5,405.00*

*Approximate acreage.

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development
Honolulu, Hawaii

November 16, 1984

Chairperson and Members
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Gentlemen:

Designation of Geothermal Resource Subzone
Haleakala Southwest Rift Zone, Island of Maui

Pursuant to Act 296, Session Laws of Hawaii 1983, and Act 151, Session Laws of Hawaii 1984, the Department of Land and Natural Resources initiated staff work in early 1983 for the designation of geothermal resource subzones in the State of Hawaii by the Board of Land and Natural Resources. The objective of establishing subzones is to allow geothermal resource exploration, development, and production of electrical energy to take place in areas having low impacts to social, economic, environmental, geological hazards, compatibility with surrounding land uses and other related aspects of interest to the communities, the County, and the State.

The Department's staff with assistance from a geothermal resource technical committee and a consultant completed the following work tasks: assessment of available information on geothermal resources in Hawaii; promulgated the Administrative Rules on geothermal resource subzones; assessment of geothermal resources in the State of Hawaii on a county-by-county basis; conducted impact analysis on social, economic, environmental, geologic hazards, compatibility to existing and planned land uses, and the relationship to other State and County programs.

The staff conducted several community meetings to discuss those areas identified as having potential geothermal resources to produce electrical energy and the various components relating to impacts to the communities, County and the State. The staff presented the information to the Board and subsequently a "Proposal for Designating Geothermal Resource Subzones" was issued by the Board in July 1984.

The Board proposed that the Haleakala Southwest Rift Zone, Island of Maui covering an area of 4154 acres be a candidate for designation as a geothermal resource subzone. Public hearings on the proposal was conducted by the Board on September 10, 1984. The majority of testimonies received were in support of the Board's proposal and are summarized as follows:

- Increased energy self-sufficiency for the State of Hawaii and less dependence on foreign fuel imports.
- The creation of new jobs and added revenue to the State.
- Development of additional industries which could utilize geothermal by-products and energy.
- Recommendation that the Board move with great urgency in the designation of geothermal resource subzones. Eliminating delays will help control costs and expedite the development of feasible alternate energy and improve the economic climate of the State.

ITEM D-6

The testimonies submitted that were in opposition to the proposal are summarized below:

- Potential health hazards and adverse effects resulting from geothermal emissions, such as air, noise and water catchment pollution.
- Potential destruction of native forests and impacts on endangered flora and fauna.
- Incompatibility with existing land uses and community setting including scenic and aesthetic qualities.

Upon review of all submitted testimonies, the staff concluded that all environmental concerns related to the designation of geothermal resource subzones can be readily mitigated through proper planning and current technology. The use of abatement systems and compliance with existing and proposed Department of Health Standards can insure public safety. In addition, appropriate mitigation measures can be required during subsequent State and County permitting to be imposed on a case-by-case basis to eliminate or minimize potential adverse effects.

The staff reviewed two testimonies as having merit for consideration in adjusting the Board's proposed area. Seibu Hawaii, Inc. recommended that the lower portion below the Kula Highway be deleted from subzone designation due to the proximity to their resort development area located approximately 2.5 miles west of the area. Mid-Pacific Geothermal Inc. recommended that the south and east boundaries of the lower portion below the Kula Highway be adjusted to include an additional area. The staff concludes that both recommendations have merit and suggests that the area below the Kula Highway be modified by deleting a portion of lands lying to the northwest and adding a portion of lands lying to the southeast. The net acreage generally remains the same by the adjustment in boundaries in the lower portion of the proposed subzone area.

RECOMMENDATION:

That the Board designate the Haleakala Southwest Rift Zone, Island of Maui, containing 4441 acres of land as a geothermal resource subzone. The boundaries of the subzone are shown on the attached Exhibit "A" and further identified by Tax Map Key in Exhibit "B".

Respectfully submitted,

Robert T. Chuck

ROBERT T. CHUCK
Manager-Chief Engineer

Attach.

APPROVED FOR SUBMITTAL:

S. Ono

SUSUMU ONO, Chairperson

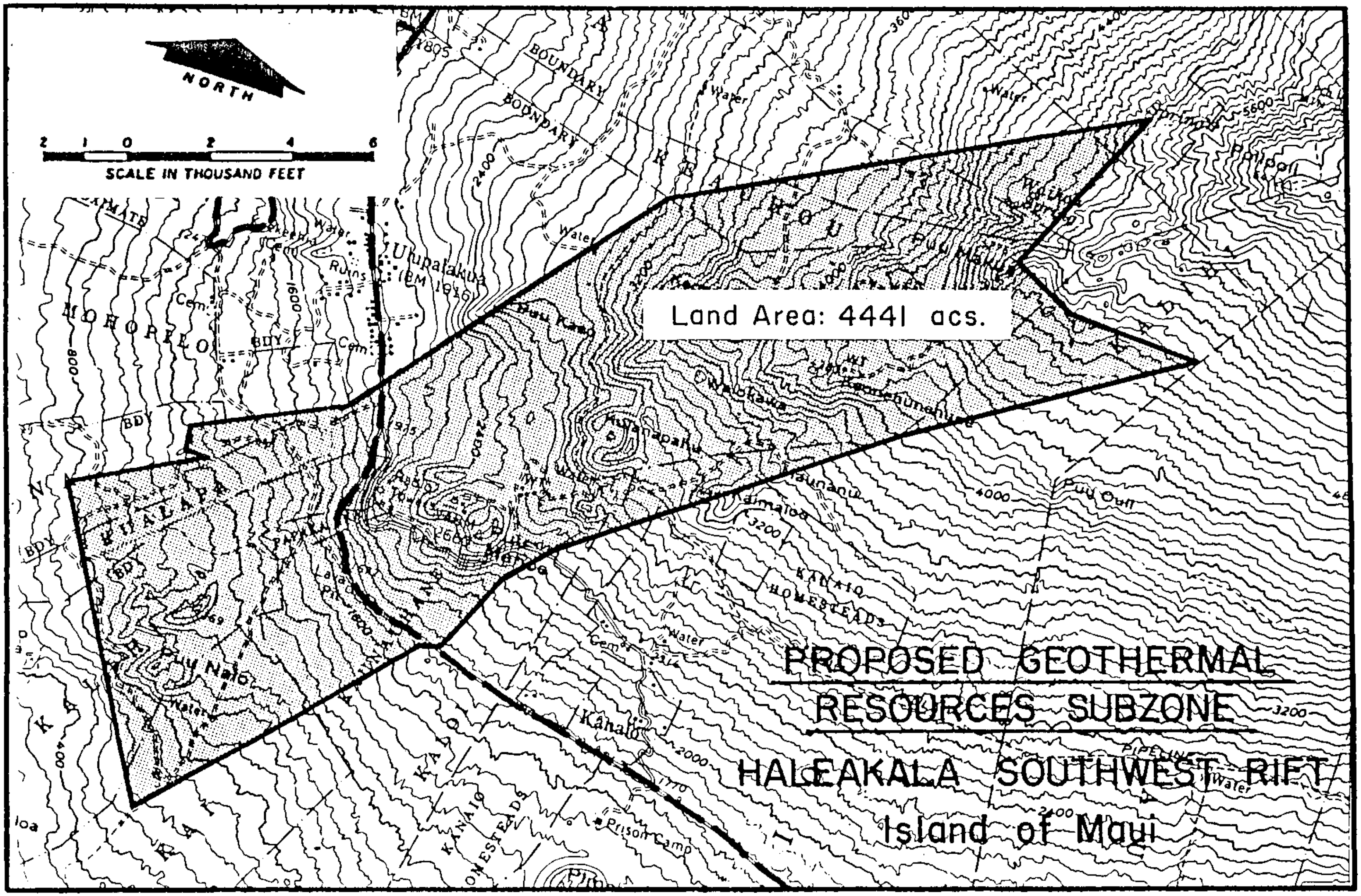

NORTH
2 1 0 2 4 6
SCALE IN THOUSAND FEET
Land Area: 4441 acs.
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
HALEAKALA SOUTHWEST RIFT
Island of Maui
BOUNDARY
Ulupalakua
Puu Naio
Kanaio
KANAIO HOMESTEADS
Prison Camp
Water
Cem.
BDY

EXHIBIT A

HALEAKALA SOUTHWEST RIFT
Island of Maui

TMK	Owner/Lessor Lessee	Area (acre)
Portion of 2-1-03-32	Goodness, Stanley K. etal Ulupalakua Ranch Inc.	1.07*
Portion of 2-1-03-50	State of Hawaii Ulupalakua Ranch Inc.	152.86*
Portion of 2-1-04-6	Ulupalakua Ranch Inc.	523.60*
2-1-04-7	Ulupalakua Ranch Inc.	24.60
2-1-04-8	Goodness, Guy S. Hew, Joseph T. Ulupalakua Ranch Inc.	110.00
2-1-04-9	Ulupalakua Ranch Inc.	57.61
2-1-04-11	Haake, Richard etal Jacintho, William etal	28.95
2-1-04-12	Ulupalakua Ranch Inc.	1.43
2-1-04-14	Page-Papazian John H/Dale L.	12.27
2-1-04-15	State of Hawaii Ulupalakua Ranch Inc.	21.34
2-1-04-16	Ulupakakua Ranch Inc.	2.22
2-1-04-17	Ulupalakua Ranch Inc.	6.98
2-1-04-18	Goodness, Stanley K. etal Hew, Joseph T. Ulupalakua Ranch Inc.	22.64
2-1-04-19	Goodness, Stanley K. etal Ulupalakua Ranch Inc.	8.21
2-1-04-20	Ulupalakua Ranch Inc.	4.22
2-1-04-21	Ulupalakua Ranch Inc.	16.10
2-1-04-22	Ulupalakua Ranch Inc.	13.38
2-1-04-23	Ulupalakua Ranch Inc.	49.27
Portion of 2-1-04-49	State of Hawaii Ulupalakua Ranch Inc.	450.79*
2-1-04-71	Ulupalakua Ranch Inc.	19.72
2-1-04-80	Fleming, Wray D. etal	6.78

EXHIBIT B

TMK	Owner/Lessor Lessee	Area (acre)
2-1-04-93	Sheets, Carl S. etal	5.25
2-1-04-94	State of Hawaii Texeira, Walter F. Aki, Charles Jr.	20.82
2-1-04-95	Crouse, Jack/Dorothy Trs.	6.12
2-1-04-96	Santiago, Lily H. Dec'd Tedeschi, Emil P.	5.10
2-1-04-97	Awai, Lizzie K. etal	3.44
2-1-04-98	Halemano, Herman, Jr. etal	8.00
2-1-04-99	Gries, Herbert A. Jr./G. etal	8.56
2-1-04-100	Luppold, George E./B.A.	3.27
2-1-04-101	Maloney, Skyler J./Cynthia M.	2.20
2-1-04-102	State of Hawaii Makimoto, Harold H.	3.00
2-1-04-103	JAL Inc. etal	4.95
2-1-04-104	JAL Inc. etal	4.59
2-1-04-105	JAL Inc. etal	9.27
Portion of 2-1-04-106	Ulupalakua Ranch Inc.	43.13*
2-1-04-107	Antone, David K. Jr. etal Ulupalakua Ranch Inc.	10.82
2-1-04-112	Makimoto, Harold H/M	4.28
2-1-04-116	Palmer, King P. Trust etal	0.14
Portion of 2-1-08-1	Ulupalakua Ranch Inc.	25.00*
Portion of 2-1-09-1	Ulupalakua Ranch Inc.	2600.00*
2-1-09-17	Vockrodt, Jack E. etal Trust	16.87
2-1-09-19	Ulupalakua Ranch Inc. Hawn Telephone Co.	.56
Portion of 2-2-01-1	Ulupalakua Ranch Inc.	22.00*
	Total	4,441.00*

*Approximate acreage.

Sherrie State Exhibit No. 13.

PROPOSAL
for
Designating Geothermal Resource Subzones
by the
Board of Land and Natural Resources

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

PROPOSAL
for
Designating Geothermal Resource Subzones
by the
Board of Land and Natural Resources

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
July 1984

GEORGE R. ARIYOSHI
Governor

BOARD OF LAND AND NATURAL RESOURCES

SUSUMU ONO, Chairperson, Member at Large

ROLAND H. HIGASHI, Hawaii Member

THOMAS S. YAGI, Maui Member

J. DOUGLAS ING, Oahu Member

MOSES W. KEALOHA, Member at Large

LEONARD H. ZALOPANY, Kauai Member

DEPARTMENT OF LAND AND NATURAL RESOURCES

SUSUMU ONO, Chairperson and Member
Board of Land and Natural Resources

EDGAR A. HAMASU, Deputy to the Chairperson

ROBERT T. CHUCK, Manager-Chief Engineer
Division of Water and Land Development

PREFACE

This proposal for designating geothermal resource subzones by the Board of Land and Natural Resources summarizes the results of a statewide assessment of potential geothermal resource areas which best demonstrate an acceptable balance of factors set forth in Act 296, SLH 1983.

The assessment was conducted by the staff of the Division of Water and Land Development with the participation of an interagency technical committee; federal, state, and county agencies; private industry; and the general public.

This proposal is published for review by the public and to receive comments at the public hearings scheduled at the following dates, places, and time:

August 7, 1984 - Pahoa Elementary School Cafetorium, Pahoa, Hawaii - 7:00 p.m.

August 8, 1984 - Hilo State Office Conference Room, Hilo, Hawaii - 9:00 a.m.

August 8, 1984 - Hawaii Volcanoes National Park, Visitor Center Auditorium - 7:00 p.m.

August 9, 1984 - Kula Elementary School, Kula Highway, Maui - 7:00 p.m.

BOARD OF LAND AND NATURAL RESOURCES

ACKNOWLEDGEMENTS

The following organizations are acknowledged for their contribution toward the this proposal:

Puna Community Council
Volcano Community Association
Ulupalakua and Kanaio Residents
Environment Capital Managers, Inc.
Hawaii County Department of Planning
Maui County Department of Public Works
Hawaiian Electric Company, Inc.
Hilo Electric and Light Company
Maui Electric Company, Ltd.
Barnwell Geothermal Corporation
Puna Joint Venture
True Geothermal Energy Company
Mid-Pacific Geothermal, Inc.
Geothermal Resources Technical Committee
Department of Health
Department of Planning & Economic Development
Hawaii Institute of Geophysics
University of Hawaii
Hawaii Volcano Observatory, USGS
U.S. Department of Energy
Planning Office, DLNR
Division of Land Management, DLNR
Division of State Parks, DLNR
Division of Forestry and Wildlife, DLNR
Division of Water and Land Development, DLNR

CONTENTS

PUBLIC INFORMATION MEETINGS

During the course of the assessment, several public information and participation meetings were held and conducted by the staff of the Division of Water and land Development. Following are the dates and places of the meetings:

May 8, 1984	-	Hilo, Hawaii
May 9, 1984	-	Kahului, Maui
May 29, 1984	-	Hilo, Hawaii
May 30, 1984	-	Kahului, Maui
July 10, 1984	-	Pahoa Community Council
July 11, 1984	-	Volcano Community Association

The Board acknowledges all the persons who participated in the public information and participation meetings.

CONCLUSIONS AND RECOMMENDATIONS

Based upon currently available information on geothermal resources, twenty separate areas in the State of Hawaii were identified as having potential geothermal resources. Of these, five sites on the island of Hawaii and two on the island of Maui were determined to have sufficient probability of locating high temperature geothermal resources with the potential of producing electrical energy. High temperature is defined to be greater than 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9,840 feet. After subjecting the seven areas to impact analysis by examining factors on geologic hazards, social and environmental impacts, compatibility with present uses of surrounding land, potential economic benefits, and compatibility with conservation areas, it is concluded that three areas warrant consideration for designation of geothermal resource subzones by the Board of land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984. The areas are described below.

Kilauea Lower East Rift, Island of Hawaii

This area shown in Figure 1 identifies two separate sites, the Kapoho section and the Kamaili section. The percent probability of locating high temperature geothermal resources has been estimated to be greater than 90 percent and the prospect for utilizing this resource is good. Relatively recent volcanic flows in the 1960's and 1970's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of the resources.

The area contains two subzones established by the Legislature in Act 151, SLH 1984.

The proposed areas provide for an approximate 2000-foot buffer zones to sensitive environmental areas, such as the Natural Area Reserve System and sensitive forest areas.

Moderate impacts are expected in scenic and aesthetic values, air quality, employment and housing needs. These impacts can be reasonably expected to be mitigated in subsequent State and County permitting processes on a case-by-case basis.

Kilauea Upper East Rift, Island of Hawaii

This area shown in Figure 2 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Significant impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to habitat the area and high quality native forest are located north of the rift zone. Moderate impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, active volcanic activity centered on Puu O has been taking place in the area. The current volcanic flows are viewed as temporary in nature and when the activity ceases, drilling over the volcanic flow is considered feasible and desirable considering the effects on other environmental values in the surrounding areas.

The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2,000-foot buffer area to both the Volcanoes National Park and the Natural Area Reserve System. In addition, the encroachment into the native forest area has been minimized to concentrate exploration, development, and production activities towards the rift or volcanic flow areas. The northern boundary extends approximately 25 percent into the native forest area.

Other moderate impacts may be readily mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

The area shown in Figure 3 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

Significant impacts expected are the scenic and aesthetic values. Moderate impacts include noise, lifestyle, culture and community setting, air quality, employment and housing needs.

The impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.

Recommendations

Based upon the above conclusions, the Board of Land and Natural Resources proposes to designate the following areas as geothermal resource subzones for the purpose of exploration, development, and production of geothermal resources:

* Kilauea Lower East Rift, Island of Hawaii
* Kilauea Upper East Rift, Island of Hawaii
* Haleakala Southwest Rift, Island of Maui

The specific areas are mapped and identified in Figures 1, 2, and 3.

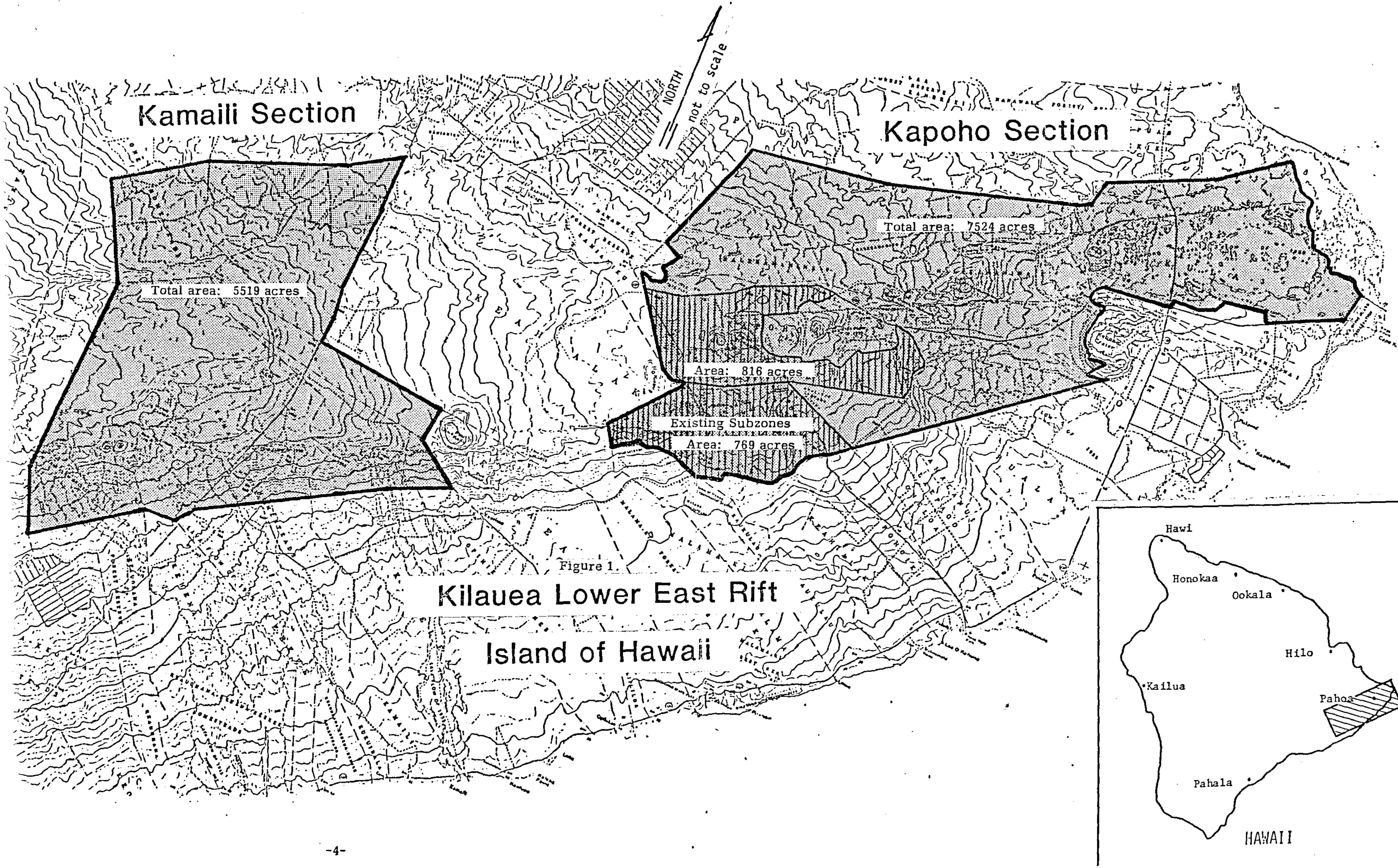
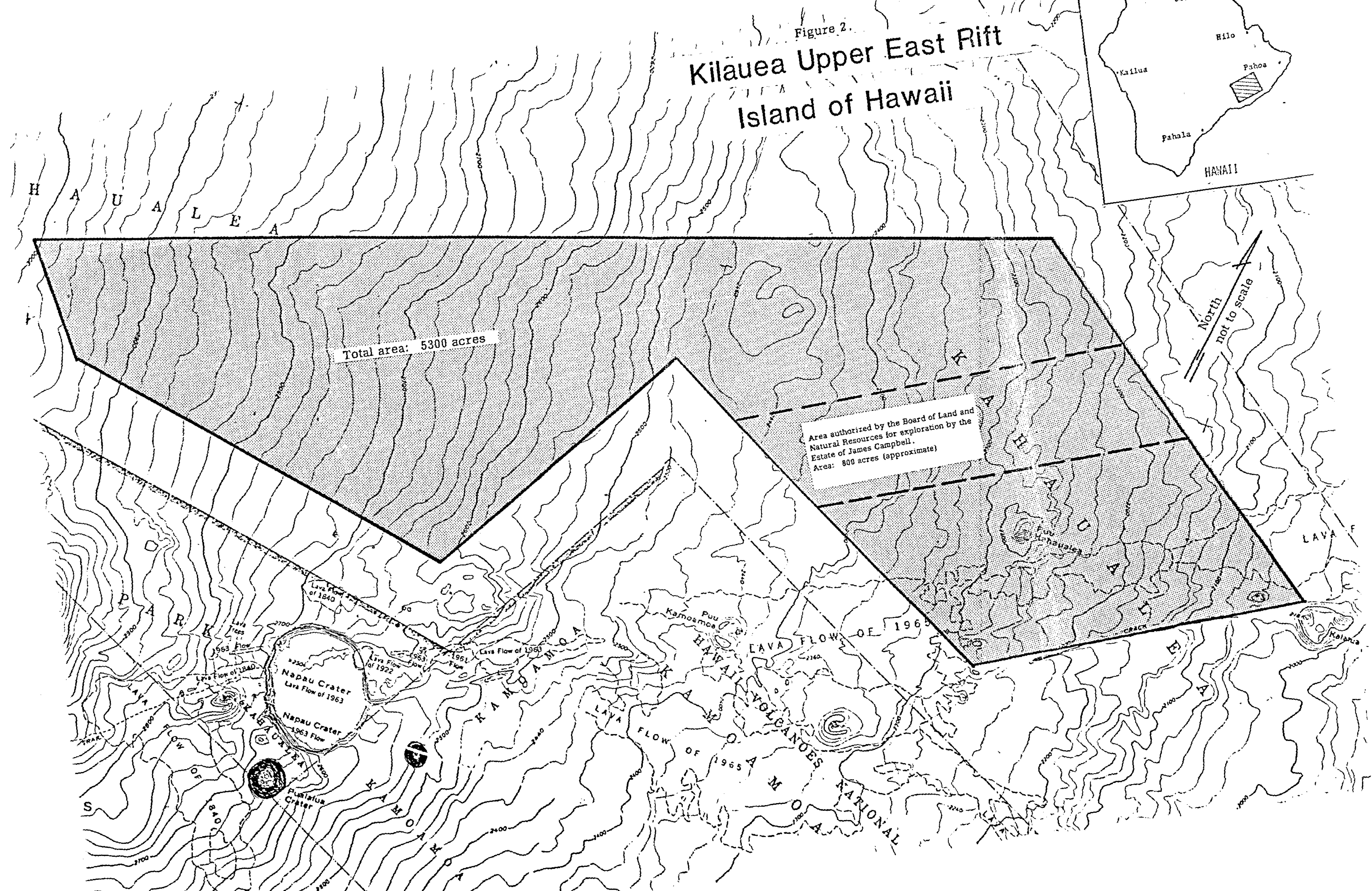


Figure 1

Kilauea Lower East Rift

Island of Hawaii

Figure 2.


Kilauea Upper East Rift
Island of Hawaii
Hilo
Kailua
Pahoa
Pahala
HAWAII
North
not to scale
Total area: 5300 acres
Area authorized by the Board of Land and Natural Resources for exploration by the Estate of James Campbell.
Area: 800 acres (approximate)
Puu Kamoamoa
Puu Huluhulu
Napau Crater
Lava Flow of 1963
Lava Flow of 1922
Lava Flow of 1840
Lava Flow of 1960
Lava Trees
Kalalua
Pualalua Crater
LAVA FLOW OF 1965
HAWAII VOLCANOES NATIONAL PARK
KAHAUALEA
KAMOAMOA

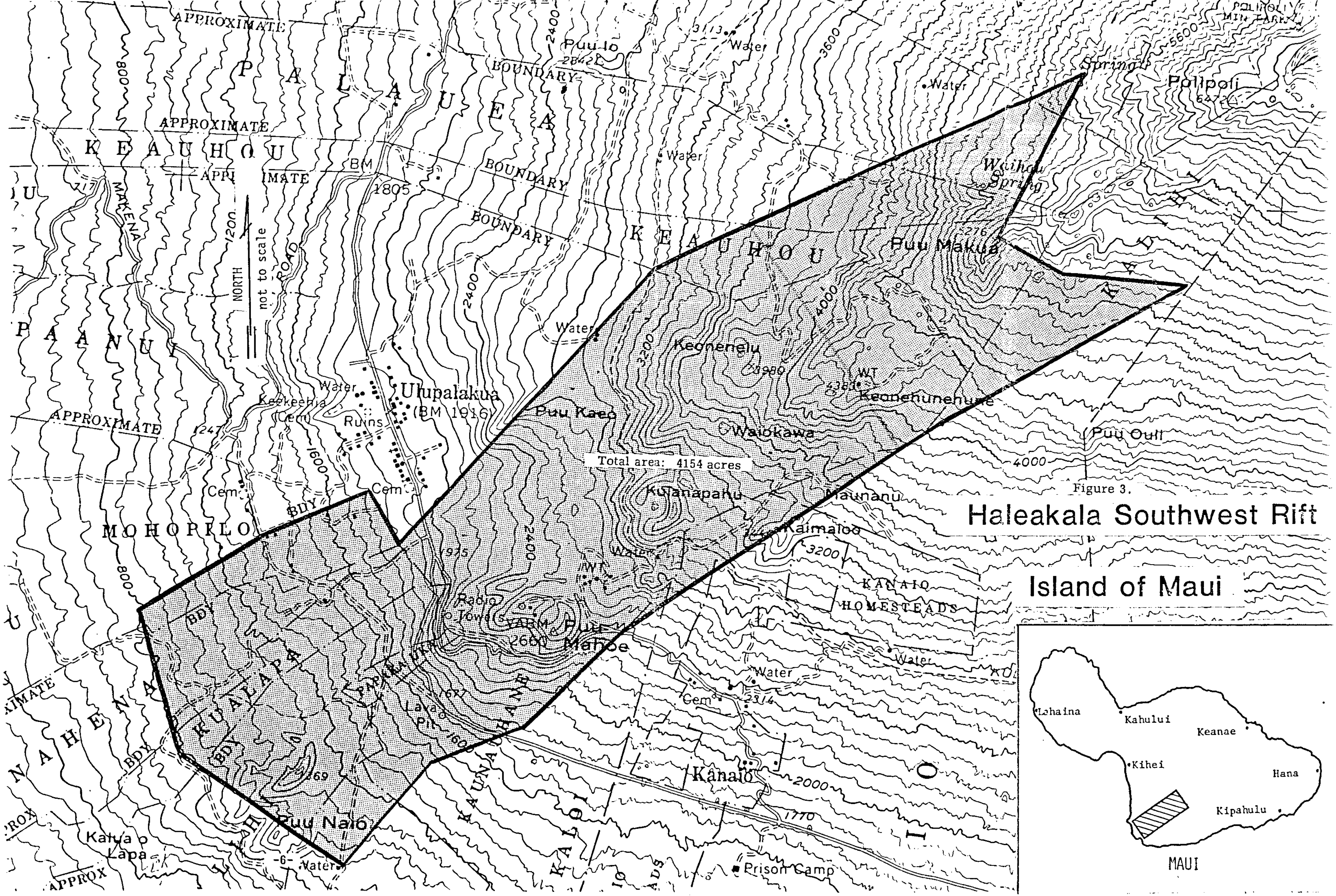


Figure 3.

Haleakala Southwest Rift

Island of Maui

INTRODUCTION

Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 by Governor George R. Ariyoshi. The legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State. Once the subzones are established, all geothermal development activities may be conducted only in these designated subzones.

LEGAL AUTHORITY

Act 296, SLH 1983, relating to geothermal energy, provides the legal basis for this assessment. The Act requires the Board of Land and Natural Resources to designate geothermal subzones. Section 3 of the Act requires the Board to "adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91." This mandate is provided for under Title 13, Chapter 184, "Designation and Regulation of Geothermal Resource Subzones" of the Department of Land and Natural Resources' Rules and Regulations. Act 151, SLH 1984, clarified various aspects of existing geothermal development activities within the State and the roles of State and County governments.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES

A Geothermal Resources Technical Committee, selected by the Department of Land and Natural Resources on the basis of their specific expertise, examined on a county-by-county basis geothermal resource areas having the potential for production of electrical energy. Due to the complexity of Hawaii's geologic structure and the variable nature of groundwater hydrology and geochemistry, the committee did not rely on just one set of data or a single set of rules. The assessment of potential for each island was based on a qualitative interpretation of several regional surveys conducted in Hawaii during the last 15 to 20 years.

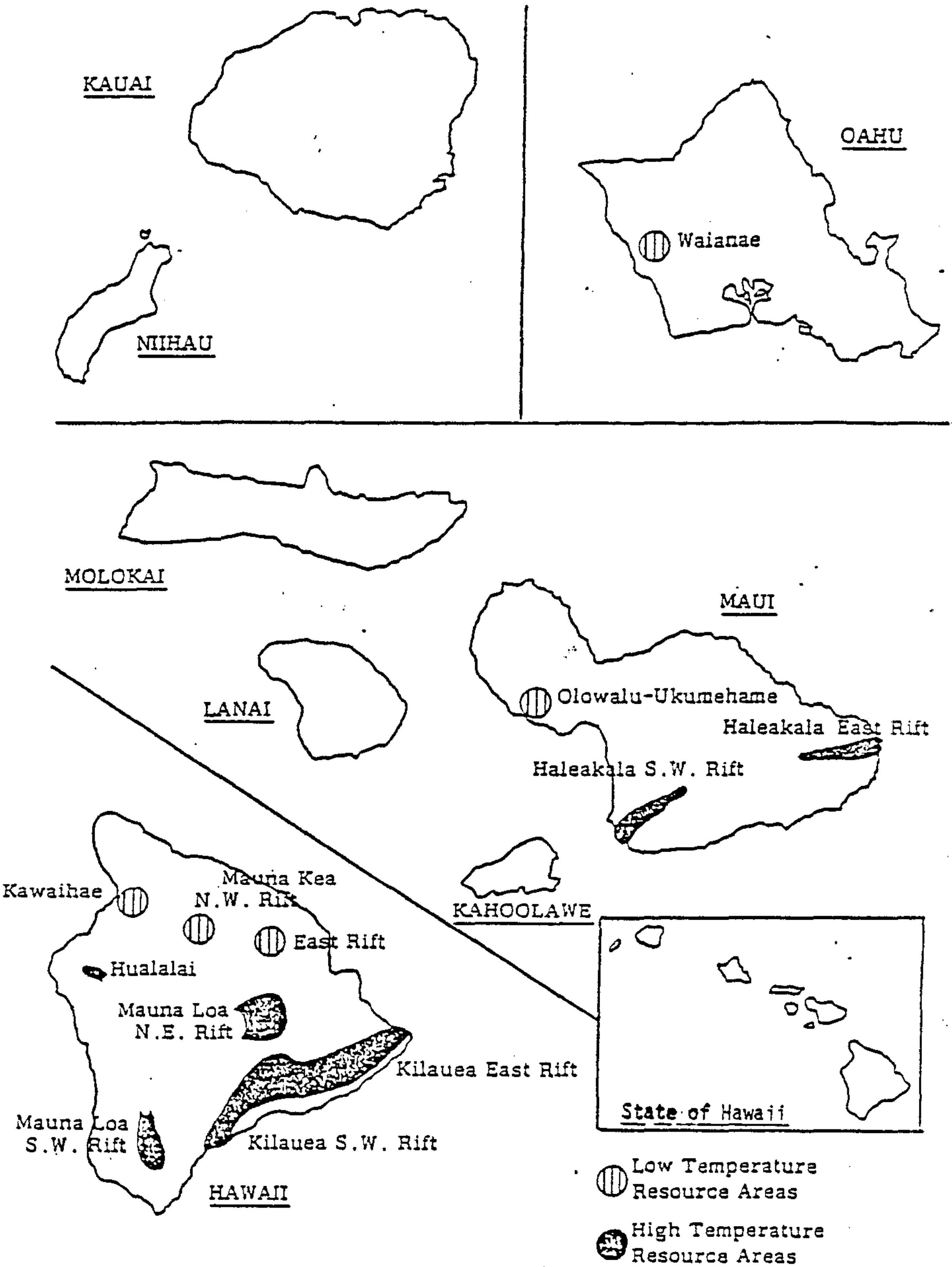
The Committee identified nine locations in Hawaii County having geothermal resources. Six locations were identified in Maui County and two in the City and County of Honolulu. Kauai, Molokai, and Lanai were determined not to have geothermal resources of any significance based upon available information. A map of the locations examined is shown in Figure 4.

Of the areas reviewed, five locations on the Island of Hawaii and two on the Island of Maui were determined to have a sufficient probability (greater than 25%) of locating a high temperature resource (greater than 125°C) at depths less than 3 kilometers. These locations are shown in Figures 5 and 6.

EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

The potential geothermal resource areas were evaluated on the basis of potential and real impacts which may occur within each of the areas. Based on available information evaluations were made of geologic hazards, social impacts, environmental impacts, compatibility of development and economic impacts. Within each of these factors, sub-factors were identified. Each of these sub-factors were evaluated as to the potential impact(s) it may have on the potential zones. This evaluation process was made on the basis of each expert's knowledge and available information obtained. The results of this evaluation process is summarized in Figure 7.

Figure 4
POTENTIAL GEOTHERMAL RESOURCE AREAS



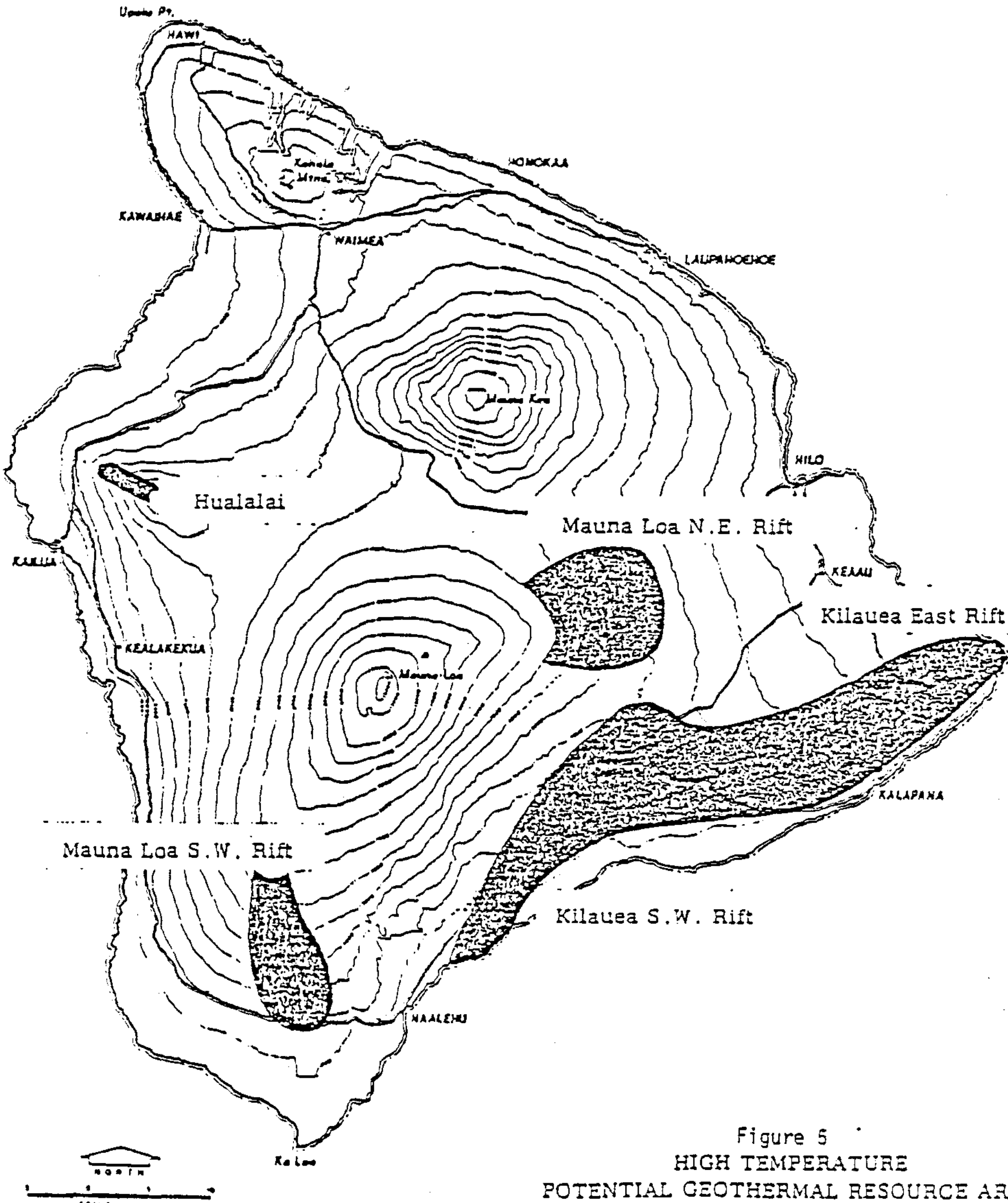


Figure 5
HIGH TEMPERATURE
POTENTIAL GEOTHERMAL RESOURCE AREA
HAWAII

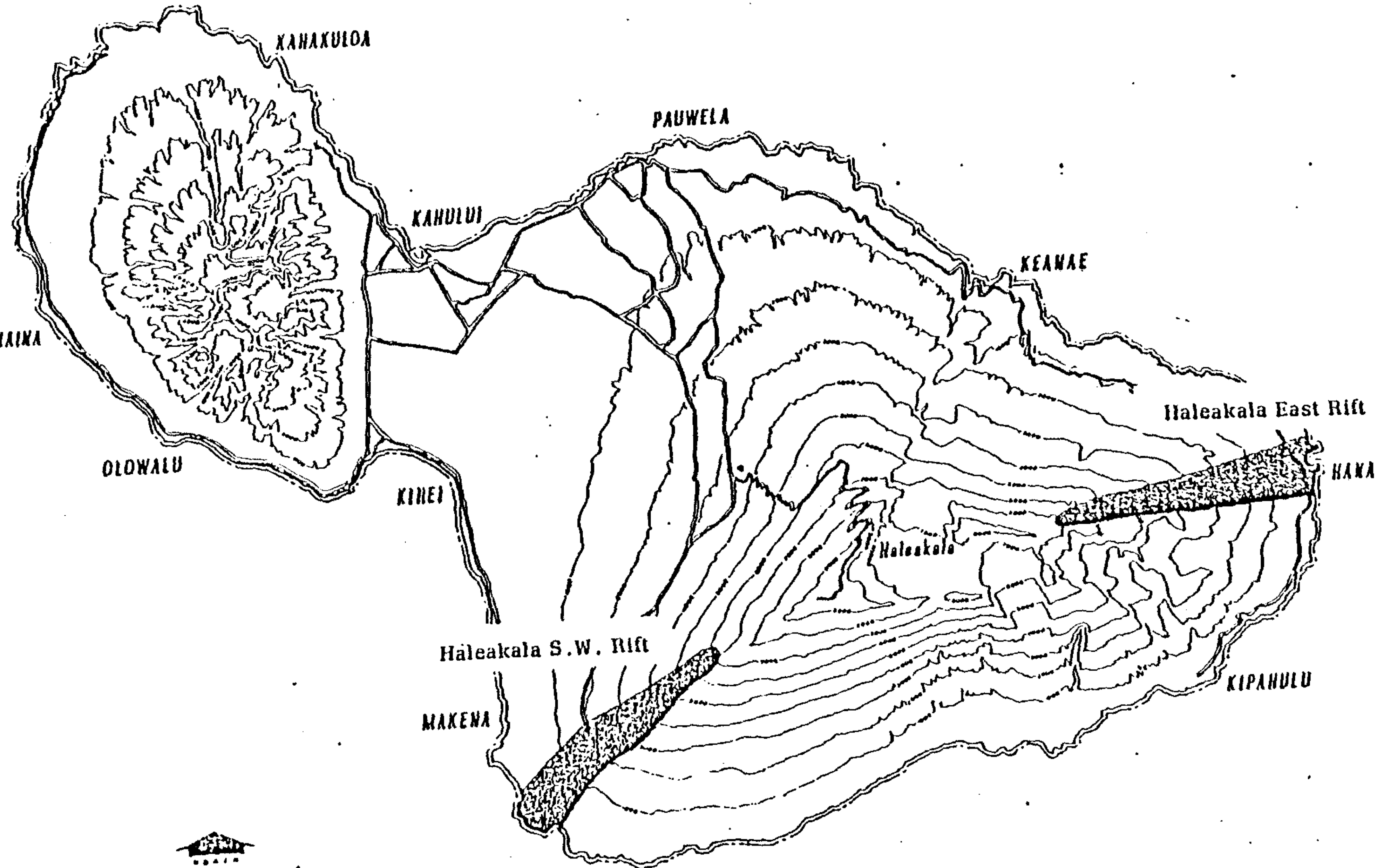


Figure 6
HIGH TEMPERATURE
POTENTIAL GEOTHERMAL RESOURCE AREA
MAUI

Figure 7. EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE SUBZONE AREAS

Basis for Evaluation	Island of Hawaii						Island of Maui	
	Kilauea East Lower	Kilauea East Upper	Kilauea Southwest	Mauna Loa Southwest	Mauna Loa Northeast	Hualalai Northwest	Haleakala East	Haleakala Southwest
Potentials for Production	+90%	+90%	+90%	35%	35%	35%	25%	25%
Prospects for Utilization	good	good	uncertain	uncertain	uncertain	uncertain	uncertain	good
Geologic Hazards Impacts								
Lava Flows	x	x						
Pyroclastic Fallout								
Ground Cracks		x						
Ground Subsidence		x						
Earthquakes								
Tsunami								
Social Impacts								
Health								
Noise							x	x
Lifestyle, Culture, Community Setting				x			x	x
Aesthetics	x	x		x	x	x	xx	xx
Environmental Impacts								
Meteorology								
Surface Water								
Ground Water								
Air Quality	x	x	x	x	x	x	x	x
Flora and Fauna		xx		xx	xx	xx	xx	
Water Quality								
Culture and Archaeological Values								
Scenic and Aesthetic Values	x	x		x	x	x	x	xx
Recreational Values								
Compatibility of Development								
State Land Use Districts		xx			xx	xx	xx	
County Zoning								
Surrounding Areas								
Present Land Uses								
Economic Impacts								
Public Revenue Sources								
Public Service Costs								
Employment	x	x	x	x	x	x	x	x
Housing	x	x		x			x	x

Key:
+90%=greater than 90% 35%=35% or less 25%=25% or less x=moderate impact expected xx=significant impact expected

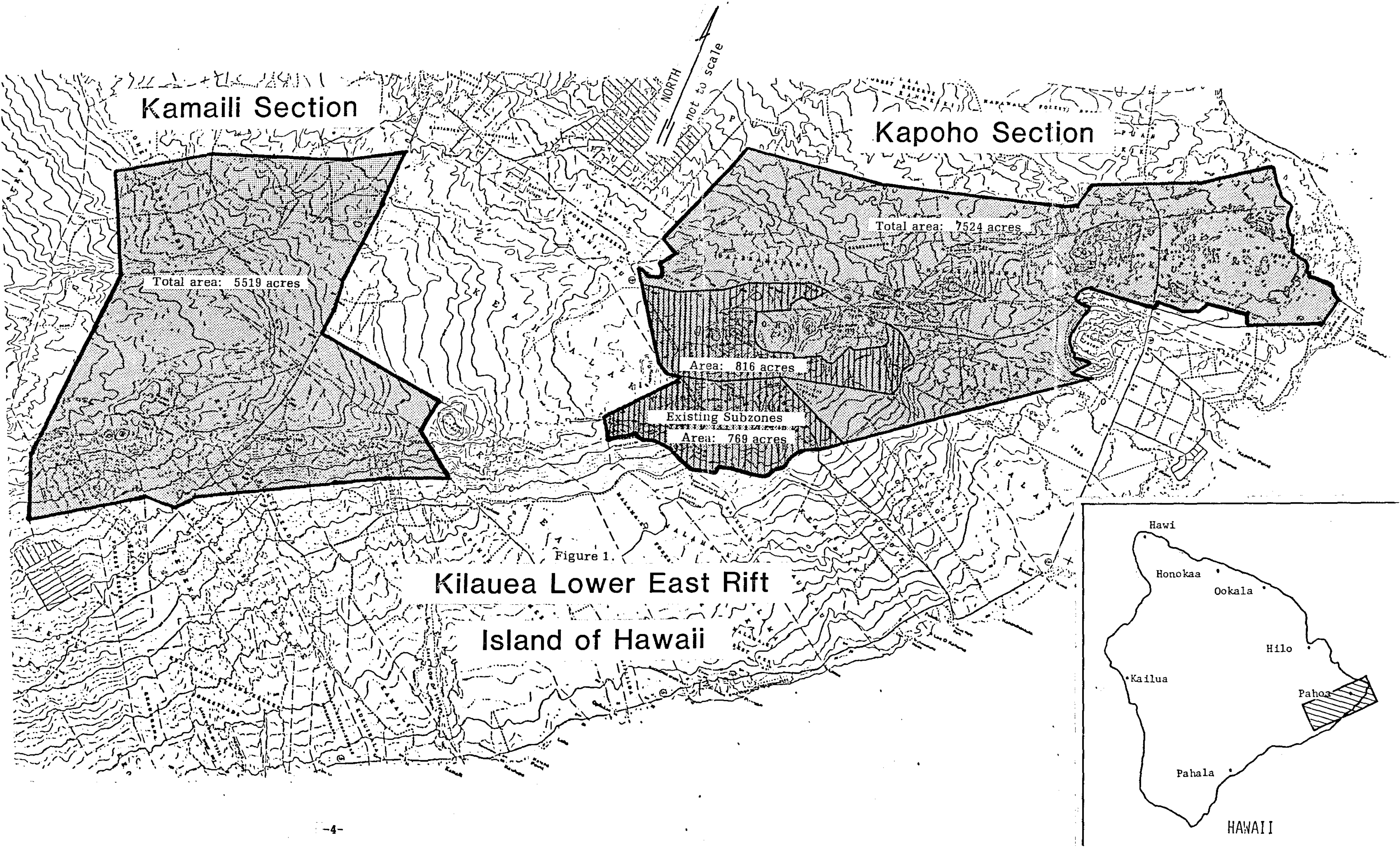


Figure 1.

Kilauea Lower East Rift

Island of Hawaii

Kilauea Lower East Rift, Hawaii

Potentials for Production

Commercially feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9,840 feet.

Prospects for Utilization

Based upon prior permit applications and developer activity, the prospects for utilization of both subzones being proposed is considered good.

Significant or Moderate Impacts

Social Impact

The principal social factors affected by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in Puna. The impact is expected to be moderate. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts

The general impact of geothermal development to the environment will be in the areas of air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

Compatibility of Development

A portion of the proposed Kapoho subzone includes two current Geothermal Resource Mining Leases, R-2 and R-3, which were declared subzones through Act 151, SLH 1984.

The proposed Kapoho subzone rests within both Land Use Commission (LUC) classified 75% as "agricultural" and 25% as "conservation, limited", due to lava flow hazards which can be mitigated. Geothermal development is considered to be of moderate significance.

Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. Based upon past growth rates in Puna, the housing situation will be tighter.

Kilauea Upper East Rift, Hawaii

Potentials for Production

Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9,840 feet.

Prospects for Utilization

Based upon prior permit applications and developer interest, the prospects for utilization of the proposed subzone is considered good.

Significant or Moderate Impacts

Geologic Hazards

At the present time, there is volcanic activity in the area especially in the 90% (chance of finding a high temperature resource) zone. In the long term, the well sites would be located near the source. Upon reasonable subsidence of lava flow activity in the future, the decision and risks of drilling would rest upon the developer.

Social Impact

The principal social factor affect by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in the Volcano area. The impact is expected to be moderate. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts

The general impact of geothermal development to the environment will be in the areas of air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

A significant impact on the flora and fauna would possibly occur within the proposed subzone area. A major portion of this subzone area consists of Category 1 forests classified as "exceptional native forest; closed canopy, over 90% native cover".

Compatibility of Development

The proposed subzone located in the upper rift zone, rests within LUC classified "conservation, limited", and geothermal development is considered to have a significant impact. Excluded from the subzone is the Hawaii Volcano National Park and the Natural Area Reserve.

Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. The housing situation will be tighter.

Kilauea Southwest Rift, Hawaii

Potentials for Production

On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater chemical anomalies, it was concluded that there was a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

Based upon available information, it is uncertain as to whether developers would drill within the proposed Pahala subzone area.

Significant Impacts

Environmental Impacts

The general impact of geothermal development to the environment will be in the area of air quality (smell). This impact is expected to be moderate.

Economic Impacts

Geothermal development in the proposed subzone will have a moderate impact on employment.

Mauna Loa Northeast Rift, Hawaii

Potentials for Production

Based on available data it was concluded that there was a 35% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

It is uncertain as to whether developers would drill for geothermal resources in this subzone area.

Significant or Moderate Impact

Social Impacts

The aesthetic impact of geothermal development would have a moderate impact on the community.

Environmental Impacts

There would be a moderate impact upon the environment in the areas of air quality (smell) and scenic/aesthetic values (visual).

Any development in the proposed subzone area would have a significant impact on the flora and fauna. Some 60% of the proposed subzone area consists of Category 1 forests, "exceptional native forest; closed canopy, with over 90% native cover". The forest area also provides habitat for various endangered forest bird species: Hawaii Creeper, Akepa, Akiapola'au, the 'O'u, and the Nene. The impact is considered to be significant.

Compatibility of Development

Some 75% of the proposed subzone area is presently classified as "conservation, protective" lands under the State Land Use District Classification. Geothermal development is considered to have a significant impact.

Economic Impact

Geothermal resource activity in this proposed subzone area should enhance employment.

Mauna Loa Southwest Rift, Hawaii

Potentials for Production

On the basis of recent historic volcanic eruptions, seismic activity and taking into consideration the absence of any other significant geophysical or geochemical anomalies, it was found that there was a 35% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

It is uncertain as to whether developers would drill for geothermal resources in this subzone area.

Significant or Moderate Impacts

Social Impacts

Geothermal development within the proposed subzone area is expected to cause changes in the lifestlye, culture and community setting within the immediate area. In addition, the aesthetics of such a development would impact upon the community. The impact of both factors are considered to be moderate.

Environmental Impacts

There would be a moderate impact on the air quality (smell) and scenic and aesthetic values (visual) due to geothermal resource development. A significant impact would entail on the fauna in this area. Approximately 50% of the proposed subzone would encompass endangered bird species--Akepa, Akiapolaau and the Hawaii Creeper.

Economic Impact

Employment would moderately increase if geothermal development takes place within the area. The housing situation will be tighter.

Hualalai Northwest Rift, Hawaii

Potentials for Production

Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologically young age of vents along the upper rift and summit, there is a 30 to 35%

chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometer.

Prospects for Utilization

It is uncertain as to whether developers would drill for geothermal resources in this subzone area.

Significant or Moderate Impacts

Social Impact

In this proposed geothermal subzone area, the impact on aesthetics expected to be moderate.

Environmental Impacts

Moderate impacts would occur in the areas of air quality (smell) and scenic and aesthetic values (visual).

Approximately 10% of the proposed subzone area consists of Category 1 forest, "exceptional native forest with over 90% native canopy cover". Species composition consist primarily of ohia lehua, koa and mamane. The fauna which inhabits the forest include the Alala, Hawaiian Creeper, Akepa and the Nene, which are considered endangered. Therefore, development in this area will have a significant impact on the flora and fauna.

Compatibility of Development

The proposed subzone area is currently classified as "conservation, protective & resource" under the State Land Use District Classification. geothermal development in this subzone area would have a significant impact.

Economic Impact

Development activity in the proposed subzone area would create a moderate increase in employment.

Haleakala Southwest Rift, Maui

Potentials for Production

Due to the geologically young age of the recent 1790 eruption and results of deep resistivity soundings, the conclusion drawn was that there is a 25% chance of finding high a temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

Based upon developer interest and activity, the prospects for utilization of the subzone area is good.

Significant or Moderate Impacts

Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal development would have a significant impact on the community.

Environmental Impacts

Air quality (smell) will have a moderate impact upon the environment. However, a significant impact would occur to scenic and aesthetic values if development occurs within the proposed subzone area.

Economic Impacts

Geothermal development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.

Haleakala East Rift, Maui

Potentials for Production

Based on the geologic age of the Hana Series lava flows, there is a 25% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers within the Haleakala East Rift Zone.

Prospects for Utilization

It is uncertain as to wheter developers would drill for geothermal resources in this subzone area.

Significant Impacts

Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal resource development would have a significant impact on the community.

Environmental Impacts

Air quality (smell) and scenic/aesthetic values will have a moderate impact upon the environment. However, the flora and fauna within the proposed subzone area will be significantly impacted. Approximately 50% of the area is Category 1 forest, "exceptional native forest, closed canopy with over 90% native cover", forest. The forested areas provide habitat for three endangered forest birds: the Maui Parrot bill, the Crested Honeycreeper, and the Akepa.

Compatibility of Development

The proposed subzone area is presently classified as "conservation, protective" under the State Land Use District Classification. Geothermal development in the proposed subzone area would have a significant impact.

Economic Impacts

Development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.

PROPOSAL

for

Designating Geothermal Resource Subzones

by the

Board of Land and Natural Resources

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

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State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
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Honolulu, Hawaii
July 1984

GEORGE R. ARIYOSHI
Governor

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ROBERT T. CHUCK, Manager-Chief Engineer
Division of Water and Land Development

PREFACE

This proposal for designating geothermal resource subzones by the Board of Land and Natural Resources summarizes the results of a statewide assessment of potential geothermal resource areas which best demonstrate an acceptable balance of factors set forth in Act 296, SLH 1983.

The assessment was conducted by the staff of the Division of Water and Land Development with the participation of an interagency technical committee; federal, state, and county agencies; private industry; and the general public.

This proposal is published for review by the public and to receive comments at the public hearings scheduled at the following dates, places, and time:

August 7, 1984 - Pahoa Elementary School Cafetorium, Pahoa, Hawaii - 7:00 p.m.

August 8, 1984 - Hilo State Office Conference Room, Hilo, Hawaii - 9:00 a.m.

August 8, 1984 - Hawaii Volcanoes National Park, Visitor Center Auditorium - 7:00 p.m.

August 9, 1984 - Kula Elementary School, Kula Highway, Maui - 7:00 p.m.

BOARD OF LAND AND NATURAL RESOURCES

ACKNOWLEDGEMENTS

The following organizations are acknowledged for their contribution toward the this proposal:

Puna Community Council
Volcano Community Association
Ulupalakua and Kanaio Residents
Environment Capital Managers, Inc.
Hawaii County Department of Planning
Maui County Department of Public Works
Hawaiian Electric Company, Inc.
Hilo Electric and Light Company
Maui Electric Company, Ltd.
Barnwell Geothermal Corporation
Puna Joint Venture
True Geothermal Energy Company
Mid-Pacific Geothermal, Inc.
Geothermal Resources Technical Committee
Department of Health
Department of Planning & Economic Development
Hawaii Institute of Geophysics
University of Hawaii
Hawaii Volcano Observatory, USGS
U.S. Department of Energy
Planning Office, DLNR
Division of Land Management, DLNR
Division of State Parks, DLNR
Division of Forestry and Wildlife, DLNR
Division of Water and Land Development, DLNR

CONTENTS

PUBLIC INFORMATION MEETINGS

During the course of the assessment, several public information and participation meetings were held and conducted by the staff of the Division of Water and land Development. Following are the dates and places of the meetings:

May 8, 1984	-	Hilo, Hawaii
May 9, 1984	-	Kahului, Maui
May 29, 1984	-	Hilo, Hawaii
May 30, 1984	-	Kahului, Maui
July 10, 1984	-	Pahoa Community Council
July 11, 1984	-	Volcano Community Association

The Board acknowledges all the persons who participated in the public information and participation meetings.

CONCLUSIONS AND RECOMMENDATIONS

Based upon currently available information on geothermal resources, twenty separate areas in the State of Hawaii were identified as having potential geothermal resources. Of these, five sites on the island of Hawaii and two on the island of Maui were determined to have sufficient probability of locating high temperature geothermal resources with the potential of producing electrical energy. High temperature is defined to be greater than 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9,840 feet. After subjecting the seven areas to impact analysis by examining factors on geologic hazards, social and environmental impacts, compatibility with present uses of surrounding land, potential economic benefits, and compatibility with conservation areas, it is concluded that three areas warrant consideration for designation of geothermal resource subzones by the Board of land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984. The areas are described below.

Kilauea Lower East Rift, Island of Hawaii

This area shown in Figure 1 identifies two separate sites, the Kapoho section and the Kamaili section. The percent probability of locating high temperature geothermal resources has been estimated to be greater than 90 percent and the prospect for utilizing this resource is good. Relatively recent volcanic flows in the 1960's and 1970's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of the resources.

The area contains two subzones established by the Legislature in Act 151, SLH 1984.

The proposed areas provide for an approximate 2000-foot buffer zones to sensitive environmental areas, such as the Natural Area Reserve System and sensitive forest areas.

Moderate impacts are expected in scenic and aesthetic values, air quality, employment and housing needs. These impacts can be reasonably expected to be mitigated in subsequent State and County permitting processes on a case-by-case basis.

Kilauea Upper East Rift, Island of Hawaii

This area shown in Figure 2 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Significant impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to in habitat the area and high quality native forest ~~are~~ is located north of the rift zone. Moderate impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, active volcanic activity centered on Puu O has been taking place in the area. The current volcanic flows are viewed as temporary in nature and when the activity ceases, drilling over the volcanic flow is considered feasible and desirable considering the effects on other environmental values in the surrounding areas.

The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2,000-foot buffer area to both the Volcanoes National Park and the Natural Area Reserve System. In addition, the encroachment into the native forest area has been minimized to concentrate exploration, development, and production activities towards the rift or volcanic flow areas. The northern boundary extends approximately 25 percent into the native forest area.

Other moderate impacts may be readily mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

The area shown in Figure 3 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

Significant impacts expected are the scenic and aesthetic values. Moderate impacts include noise, lifestyle, culture and community setting, air quality, employment and housing needs.

The impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.

Recommendations

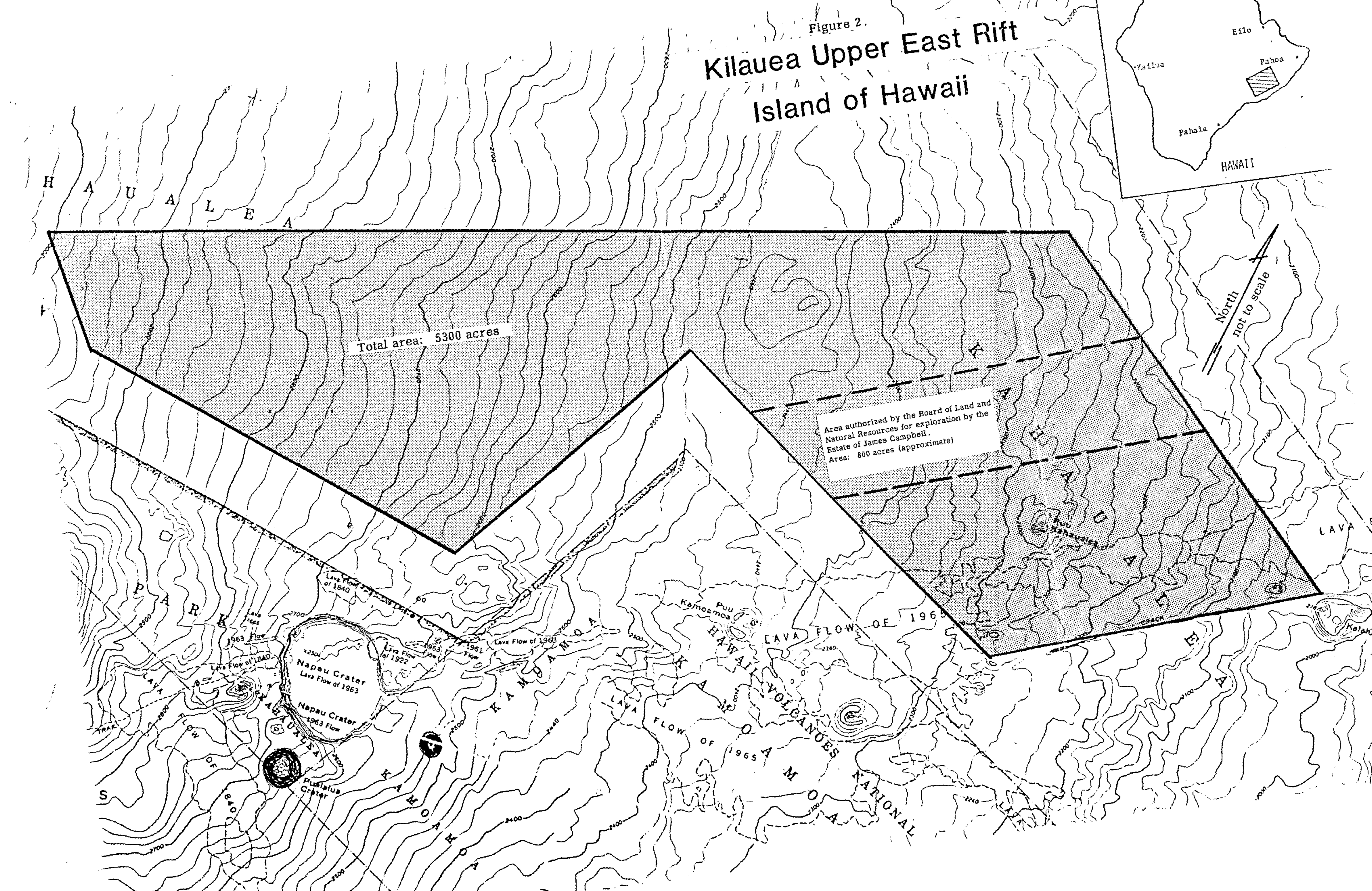
Based upon the above conclusions, the Board of Land and Natural Resources proposes to designate the following areas as geothermal resource subzones for the purpose of exploration, development, and production of geothermal resources:

* Kilauea Lower East Rift, Island of Hawaii
* Kilauea Upper East Rift, Island of Hawaii
* Haleakala Southwest Rift, Island of Maui

The specific areas are mapped and identified in Figures 1, 2, and 3.

Figure 2.

Kilauea Upper East Rift Island of Hawaii



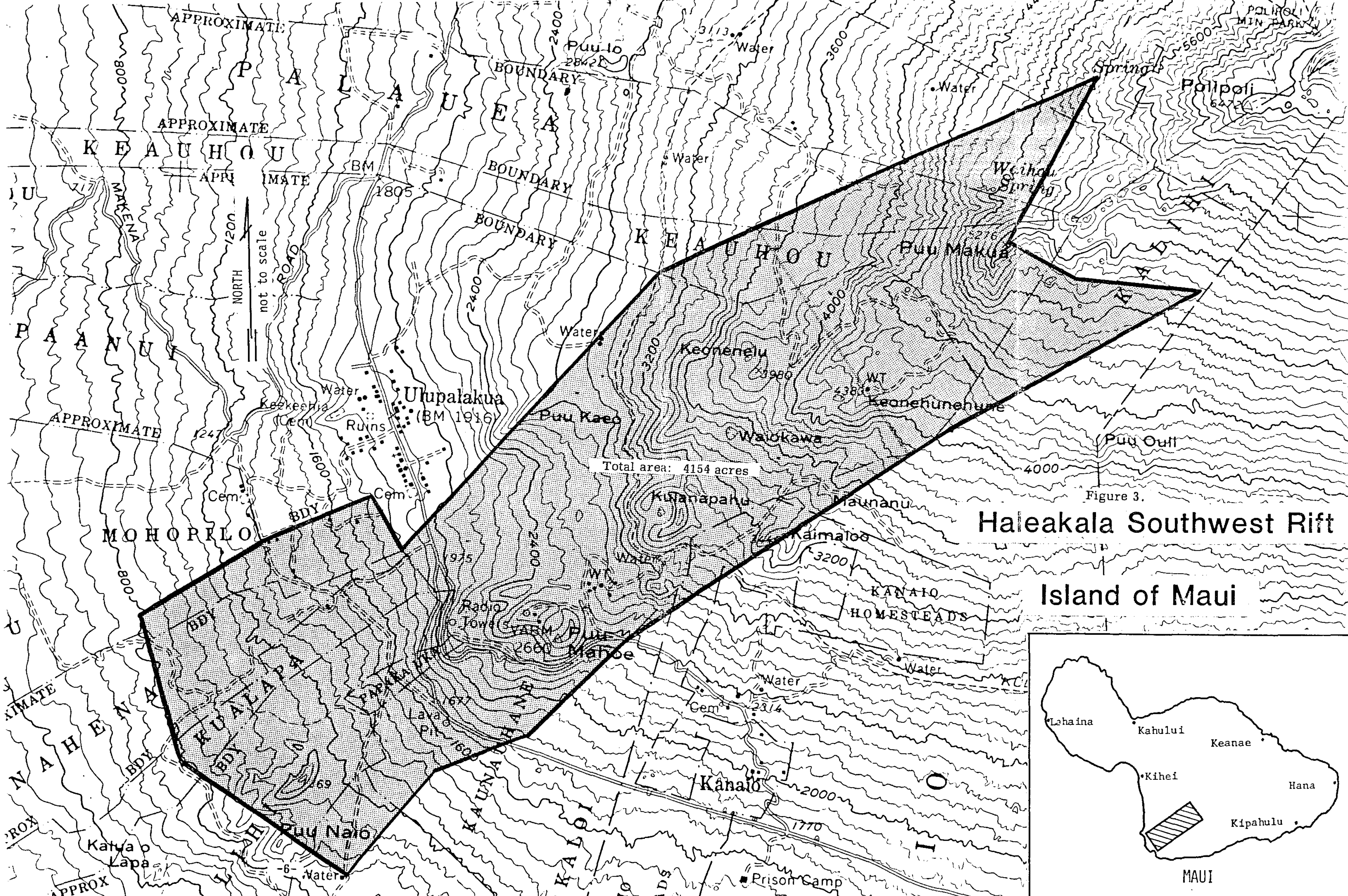


Figure 3.

Haleakala Southwest Rift

Island of Maui

INTRODUCTION

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The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State. Once the subzones are established, all geothermal development activities may be conducted only in these designated subzones.

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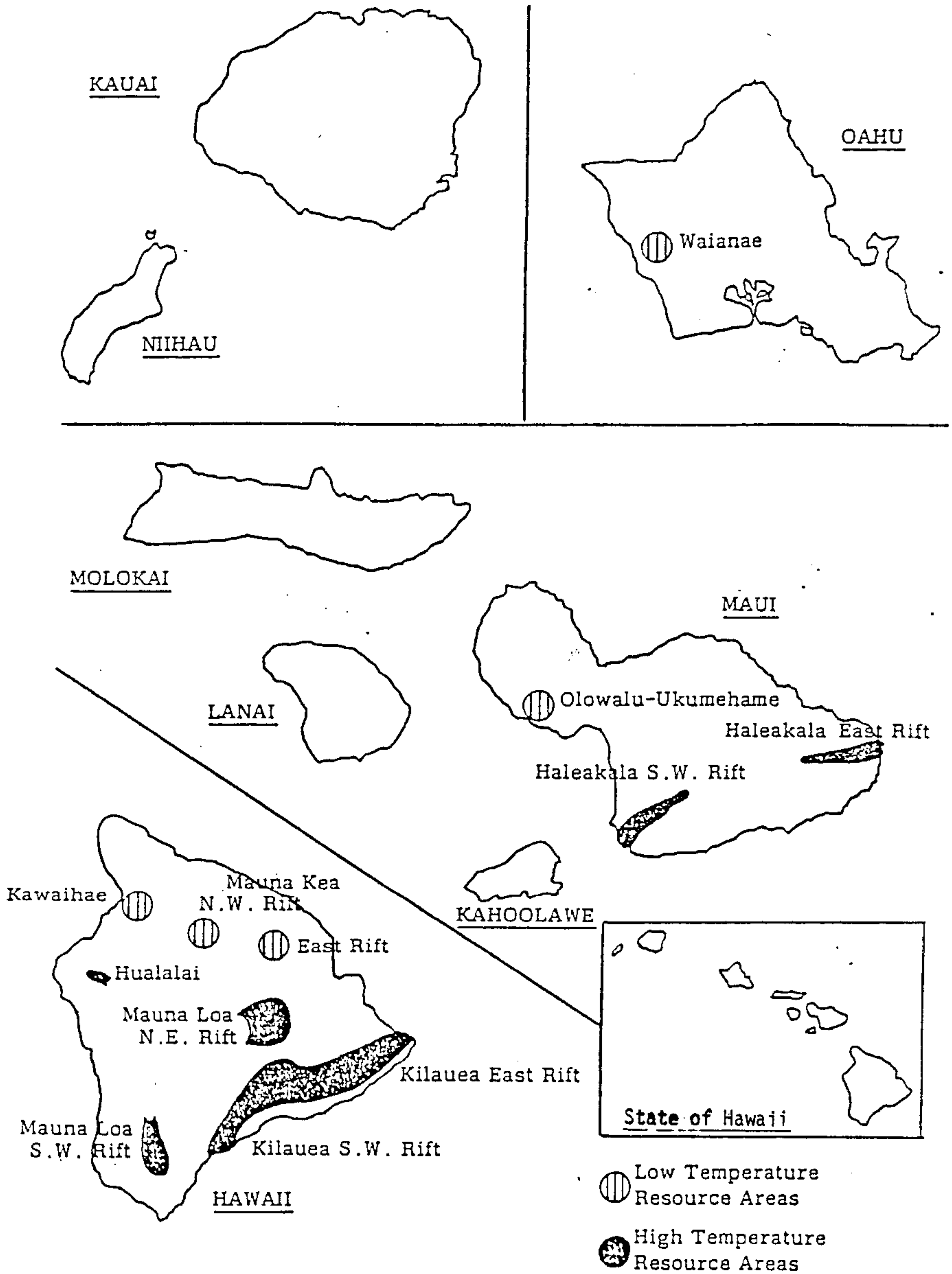

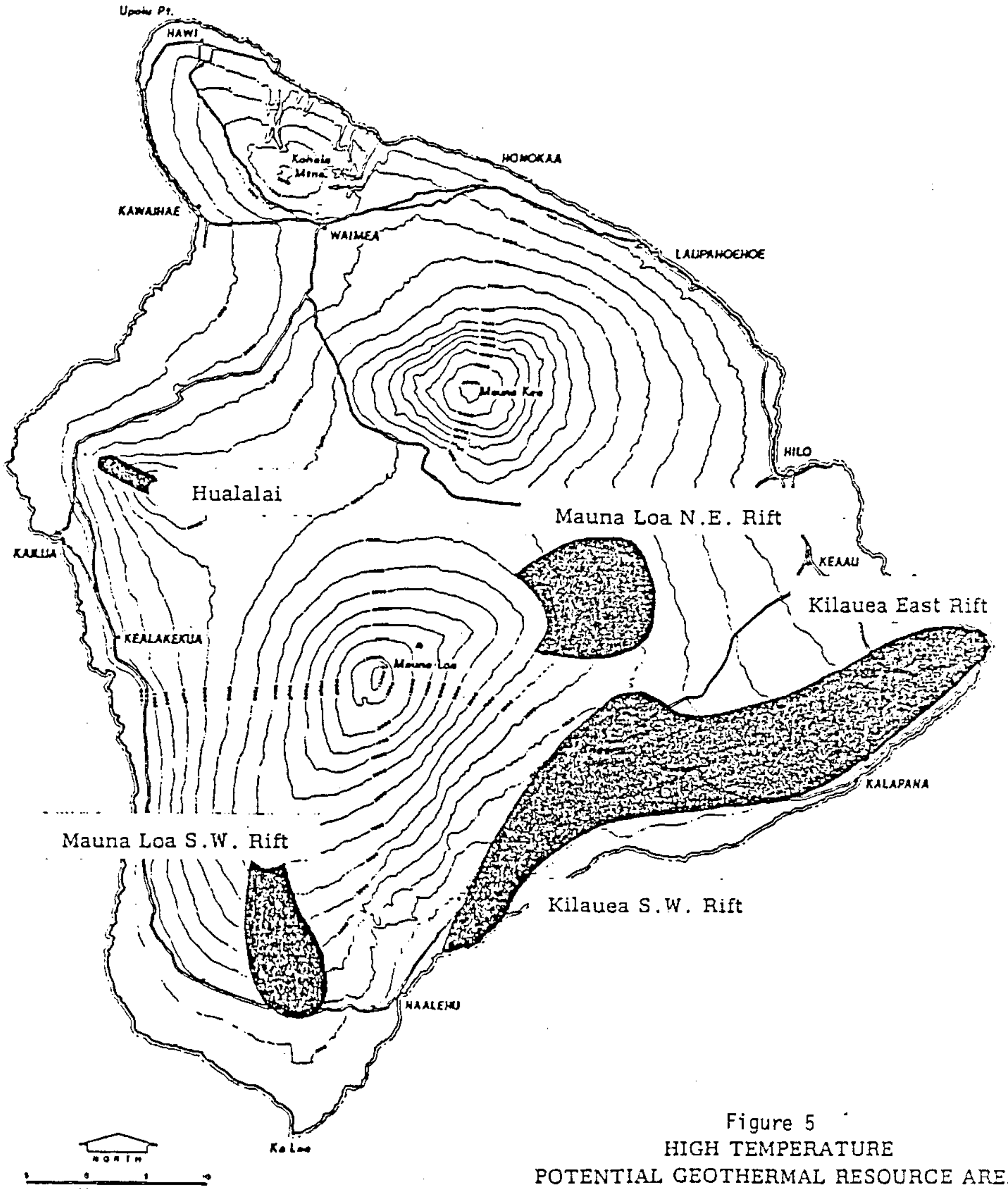

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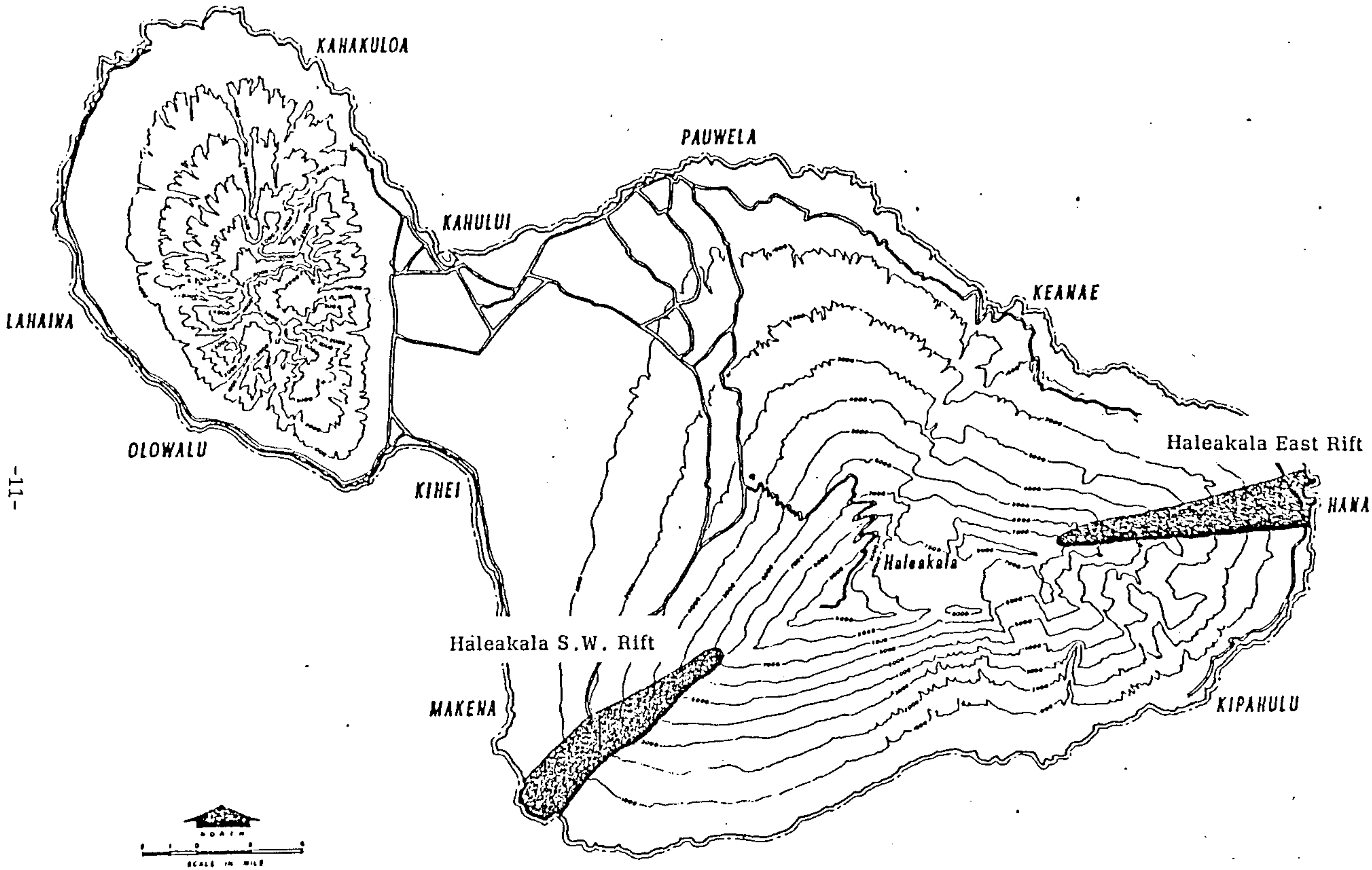

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Noise							x	x
Lifestyle, Culture, Community Setting				x			x	x
Aesthetics	x	x		x	x	x	xx	xx
Environmental Impacts								
Meteorology								
Surface Water								
Ground Water								
Air Quality	x	x	x	x	x	x	x	x
Flora and Fauna		xx		xx	xx	xx	xx	
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Scenic and Aesthetic Values	x	x		x	x	x	x	xx
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Public Service Costs								
Employment	x	x	x	x	x	x	x	x
Housing	x	x		x			x	x

Key:
+90%=greater than 90% 35%=35% or less 25%=25% or less x=moderate impact expected xx=significant impact expected

Kilauea Lower East Rift, Hawaii

Potentials for Production

Commercially feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9,840 feet.

Prospects for Utilization

Based upon prior permit applications and developer activity, the prospects for utilization of both subzones being proposed is considered good.

Significant or Moderate Impacts

Social Impact

The principal social factors affected by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in Puna. The impact is expected to be moderate. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts

The general impact of geothermal development to the environment will be in the areas of air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

Compatibility of Development

A portion of the proposed Kapoho subzone includes two current Geothermal Resource Mining Leases, R-2 and R-3, which were declared subzones through Act 151, SLH 1984.

The proposed Kapoho subzone rests within both Land Use Commission (LUC) classified 75% as "agricultural" and 25% as "conservation, limited", due to lava flow hazards which can be mitigated. Geothermal development is considered to be of moderate significance.

Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. Based upon past growth rates in Puna, the housing situation will be tighter.

Kilauea Upper East Rift, Hawaii

Potentials for Production

Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9,840 feet.

Prospects for Utilization

Based upon prior permit applications and developer interest, the prospects for utilization of the proposed subzone is considered good.

Significant or Moderate Impacts

Geologic Hazards

At the present time, there is volcanic activity in the area especially in the 90% (chance of finding a high temperature resource) zone. In the long term, the well sites would be located near the source. Upon reasonable subsidence of lava flow activity in the future, the decision and risks of drilling would rest upon the developer.

Social Impact

The principal social factor affect by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in the Volcano area. The impact is expected to be moderate. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts

The general impact of geothermal development to the environment will be in the areas of air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

A significant impact on the flora and fauna would possibly occur within the proposed subzone area. A major portion of this subzone area consists of Category 1 forests classified as "exceptional native forest; closed canopy, over 90% native cover".

Compatibility of Development

The proposed subzone located in the upper rift zone, rests within LUC classified "conservation, limited", and geothermal development is considered to have a significant impact. Excluded from the subzone is the Hawaii Volcano National Park and the Natural Area Reserve.

Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. The housing situation will be tighter.

Kilauea Southwest Rift, Hawaii

Potentials for Production

On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater chemical anomalies, it was concluded that there was a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

Based upon available information, it is uncertain as to whether developers would drill within the proposed Pahala subzone area.

Significant Impacts

Environmental Impacts

The general impact of geothermal development to the environment will be in the area of air quality (smell). This impact is expected to be moderate.

chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometer.

Prospects for Utilization

It is uncertain as to whether developers would drill for geothermal resources in this subzone area.

Significant or Moderate Impacts

Social Impact

In this proposed geothermal subzone area, the impact on aesthetics expected to be moderate.

Environmental Impacts

Moderate impacts would occur in the areas of air quality (smell) and scenic and aesthetic values (visual).

Approximately 10% of the proposed subzone area consists of Category 1 forest, "exceptional native forest with over 90% native canopy cover". Species composition consist primarily of ohia lehua, koa and mamane. The fauna which inhabits the forest include the Alala, Hawaiian Creeper, Akepa and the Nene, which are considered endangered. Therefore, development in this area will have a significant impact on the flora and fauna.

Compatibility of Development

The proposed subzone area is currently classified as "conservation, protective & resource" under the State Land Use District Classification. geothermal development in this subzone area would have a significant impact.

Economic Impact

Development activity in the proposed subzone area would create a moderate increase in employment.

Haleakala Southwest Rift, Maui

Potentials for Production

Due to the geologically young age of the recent 1790 eruption and results of deep resistivity soundings, the conclusion drawn was that there is a 25% chance of finding high a temperature (greater`than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization

Based upon developer interest and activity, the prospects for utilization of the subzone area is good.

Significant or Moderate Impacts

Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal development would have a significant impact on the community.

Environmental Impacts

Air quality (smell) will have a moderate impact upon the environment. However, a significant impact would occur to scenic and aesthetic values if development occurs within the proposed subzone area.

Economic Impacts

Geothermal development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.

Haleakala East Rift, Maui

Potentials for Production

Based on the geologic age of the Hana Series lava flows, there is a 25% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers within the Haleakala East Rift Zone.

Prospects for Utilization

It is uncertain as to wheter developers would drill for geothermal resources in this subzone area.

Significant Impacts

Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal resource development would have a significant impact on the community.

Environmental Impacts

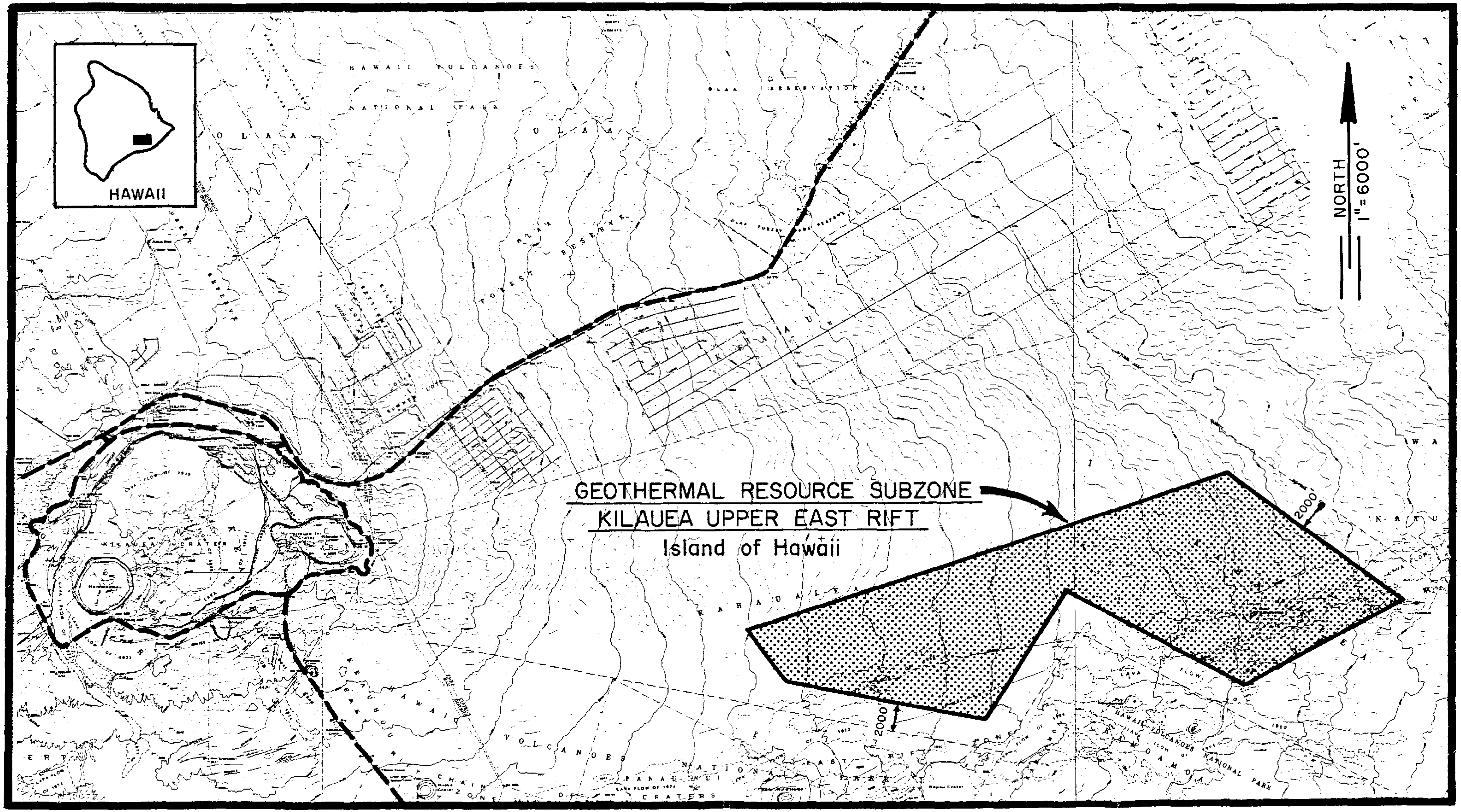
Air quality (smell) and scenic/aesthetic values will have a moderate impact upon the environment. However, the flora and fauna within the proposed subzone area will be significantly impacted. Approximately 50% of the area is Category 1 forest, "exceptional native forest, closed canopy with over 90% native cover", forest. The forested areas provide habitat for three endangered forest birds: the Maui Parrot bill, the Crested Honeycreeper, and the Akepa.

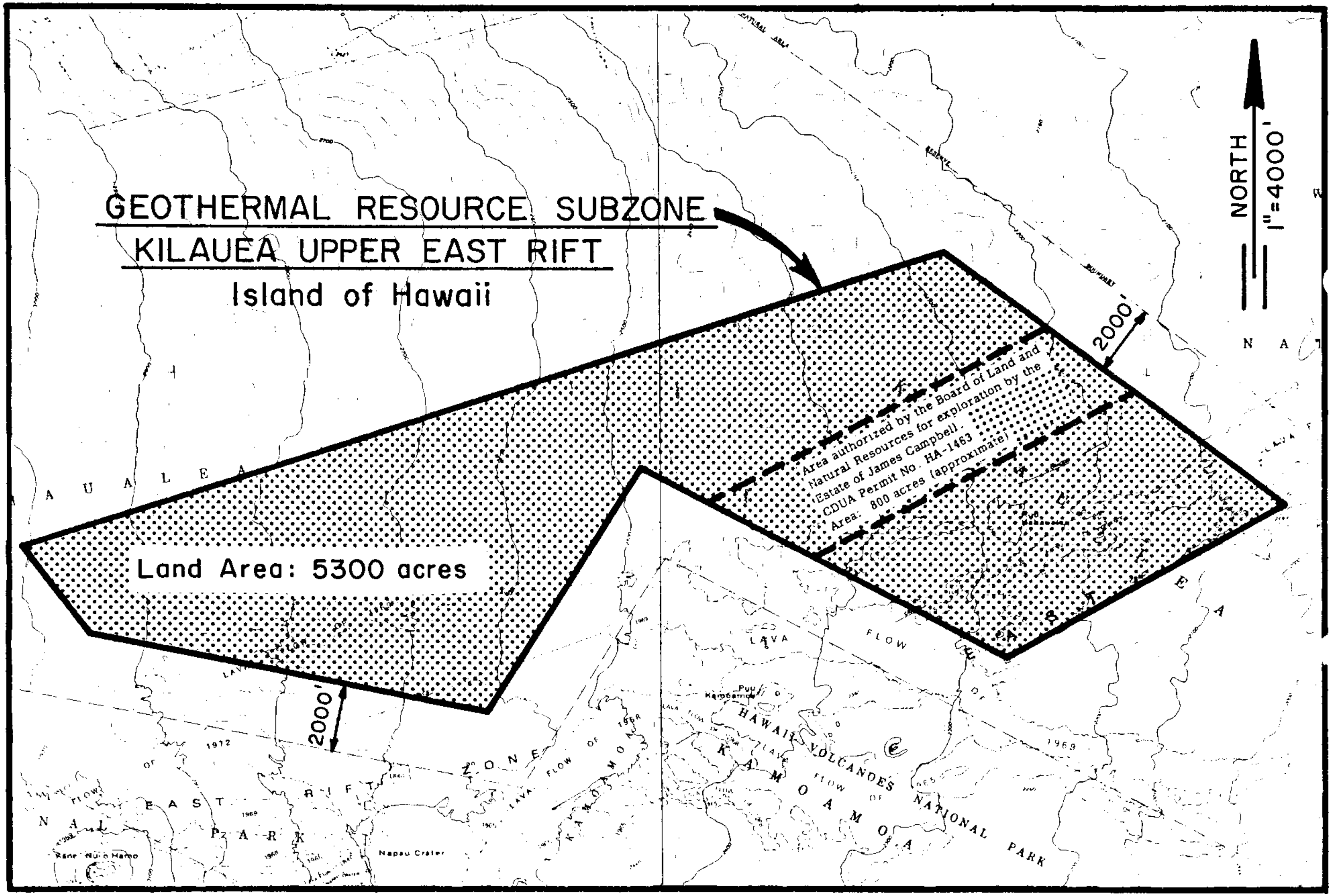
Compatibility of Development

The proposed subzone area is presently classified as "conservation, protective" under the State Land Use District Classification. Geothermal development in the proposed subzone area would have a significant impact.

Economic Impacts

Development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.


GEOTHERMAL RESOURCE SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii
HAWAII
NORTH
1"=6000'
HAWAII VOLCANOES
NATIONAL PARK
OLAA
OLAA RESERVATION LOTS
OLAA FOREST RESERVE
KILAUEA CRATER
2000'
2000



GEOTHERMAL RESOURCE SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii
Land Area: 5300 acres
Area authorized by the Board of Land and Natural Resources for exploration by the Estate of James Campbell
CDUA Permit No. HA-1463
Area: 800 acres (approximate)
2000'
2000'
NORTH
1"=4000'
EAST RIFT ZONE
HAWAII VOLCANOES NATIONAL PARK
Napau Crater

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Upper East Rift, Island of Hawaii, as a Geothermal Resource Subzone	G.S. No. 8/27/84-1

Decision and Order on the Proposed Geothermal Resource Subzone at Kahauale'a, Hawaii

Decision and Order of the Board of Land and Natural Resources on the Proposed Geothermal Resource Subzone at Kahauale'a, Hawaii

Pursuant to Act 296, SLH 1983, Act 151, SLH 1984 and Title 13, Chapter 184 of the administrative rules of the Department of Land and Natural Resources, the Board of Land and Natural Resources has been assessing potential geothermal resource areas throughout the State. Under Act 151, SLH 1984, two areas in lower Puna, Hawaii, with existing wells were grandfathered as geothermal resource subzones. On November 16, 1984, this Board designated two additional subzone areas in lower Puna on the Island of Hawaii and one on the southwest rift of Haleakala, Maui.

Today the Board is acting upon a proposal to designate a portion of land at Kahauale'a, Hawaii. In consideration of the widespread interest which this proposal generated, the Board in its discretion conducted a contested case hearing from December 12-20, 1984 in Hilo, Hawaii. Parties to those hearings submitted their proposed findings of fact and conclusions of law to the Board this past Monday, December 24, 1984.

Under Act 151, SLH 1984, the Board must make a determination by December 31, 1984 regarding the designation of all or any portion of the land which the Board approved in its Conservation District Use Permit of February 25, 1984. That decision allowed Campbell Estate to conduct limited exploration on approximately 800 acres of land in Kahauale'a. The Board has reviewed and considered the proposed findings of fact and conclusions of law submitted by the parties. In view of the statutory deadline and the brief time available to the Board since it received the proposed findings, the decision today will be rendered orally. A full written decision and order will follow at a later date.

I. The Board of Land and Natural Resources approves the designation of the area described in the Board's Decision and Order of February 25, 1983 containing approximately 800 acres of surface area as a geothermal resource subzone upon the occurrence of the following events and upon the following conditions:

1. The cessation of volcanic acitivity in, around, and near the area permitted by the Board's February 25, 1983 Decision and Order. The determination that eruptive activity constituting a geologic hazard has ceased shall be made by the Board upon evidence and testimony from professional geologists from the Hawaii Volcanoes Observatory and the U. S. Geological Survey. Other professional geologists with special experience in this particular geographic area may be heard at the Board's discretion.

2. No new activity associated with the permitted area shall be considered until after the determination is made that geologically hazardous and eruptive activity in, near, and around the permitted area has ceased as provided for above.

II. The State of Hawaii formally requests the Estate of James Campbell to investigate and consider a land exchange involving State owned land in Kilauea middle east rift zone and Campbell Estate's lands at Kahauale'a (excluding Tract 22).

If the State of Hawaii and Campbell Estate should later consummate a land exchange involving lands at Kahauale'a for State or other lands upon which geothermal activities may take place, then the geothermal subzone designation in this Decision and Order shall cease to exist and shall have no force or effect in law, notwithstanding any further requirement for a contested case hearing in HRS 205-5.2(~~3~~) or any other provision of law to the contrary.

e.

III. The Board of Land and Natural Resources on its own motion hereby directs the Division of Water and Land Development (DOWALD) of the Department of Land and Natural Resources (DLNR) to immediately undertake and conduct an assessment of the Kilauea middle east rift zone in and adjacent to the Natural Area Reserve beginning on the western boundary of the Kamaili geothermal subzone as a potential geothermal resource subzone. Although this area had not previously been evaluated due to its classification as a Natural Area Reserve, the Board now believes that the area should be reviewed.

IV. If a) the assessment of the Kilauea middle east rift zone does not result in a designation as a geothermal resource subzone in this area; or b) a land exchange between the State of Hawaii and the Estate of James Campbell is not consummated then the remainder of the 5300 acres proposed by DOWALD as a geothermal resource subzone in Kahauale'a heretofore not designated by this Decision and Order shall be and is hereby ordered to be so designated as a geothermal resource subzone.

V. If the land exchange described above is consummated, the Board of Land and Natural Resources strongly urges the federal government and the National Park Service to immediately seek to acquire Tract 22 (as described on its Master Plan), which the State will not itself seek.

VI. If the exchange described above does occur, the entire 5300 acres within the proposed subzone (exclusive of Tract 22) shall be included within the lands acquired by the State of Hawaii from Campbell Estate and shall be eliminated from the proposed subzone.

Honolulu, Hawaii December 28, 1984.

IT IS SO ORDERED.

By the Board of Land and Natural Resources

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

MOSES KEALOHA

ROLAND HIGASHI

THOMAS YAGI

Decision and Order on the Proposed Geothermal Resource Subzone at Kahauale'a, Hawaii.

NOTICE OF A CONTESTED CASE HEARING
BEFORE THE BOARD OF LAND AND NATURAL RESOURCES
ON THE PROPOSED DESIGNATION OF A PORTION OF
THE KILAUEA UPPER EAST RIFT ZONE (KAHAUALEA)
AS A GEOTHERMAL RESOURCE SUBZONE

Pursuant to Chapter 91, HRS, and Chapters 205-5.1 and 205-5.2, HRS, as amended by Act 151, SLH 1984, and Title 13, Chapters 1 and 184, Administrative Rules, as amended, the Board of Land and Natural Resources, State of Hawaii, will conduct a contested case hearing on the proposed designation of approximately 5,300 acres at Kahaualea, Puna, Hawaii (TMK: 1-1-01:1), as a Geothermal Resource Subzone. The contested case hearing will commence on December 12, 1984 at 9:00 a.m. in the Conference Room of the Hilo Union School Annex, 450 Waianuenue Avenue, Hilo, Hawaii.

Any person wishing to participate in the hearing as an intervening party must file an application in conformance with Department of Land and Natural Resources Rule 13-1-31 explaining briefly how he or she has a specific legal interest different from the public generally and how their interest could be affected by the proposed action. Any party may retain counsel if desired. An individual may appear on his own behalf, or a member of a partnership may represent the partnership, or an officer or authorized employee of a corporation or trust or association may represent the corporation, trust, or association. All parties shall be afforded the opportunity to present and cross-examine evidence and witnesses and to make arguments on issues before the Board.

A copy of the Proposal outlining the facts and issues involved in the Kilauea Upper East Rift Subzone designation as well as other information is available at the Department of Land and Natural Resources offices in Honolulu and Hilo.

The record of In Re the CDUA of the Estate of James Campbell (CDUA No. HA-3/2/82-1463) will be incorporated by reference. Only new evidence not previously presented will be received. Argument may incorporate any prior evidence.

Written applications to intervene must be actually received no later than 9:00 a.m., November 30, 1984, at the Chairman's Office of the Board of Land and Natural Resources in Honolulu for consideration.

BOARD OF LAND & NATURAL RESOURCES

SUSUMU ONO
Chairperson of the Board

Dated: November 9, 1984

Publication Dates: November 16 and 21, 1984

THE HONOLULU STAR BULLETIN
HAWAII TRIBUNE HERALD

STATEWIDE GEOTHERMAL RESOURCE ASSESSMENT

Circular C-103

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
September 1984

Honorable Susumu Ono, Chairperson
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Dear Mr. Ono:

Transmitted herewith for your consideration is the Statewide Geothermal Resource Assessment report prepared in response to your charge that the Technical Committee review available information and recommend areas in the State where geothermal resources might be available for electrical power generation.

The report makes a statewide, county-by-county assessment of Hawaii's potential geothermal resource areas, based on currently available geotechnical information.

Presented are the Committee's recommendations for high temperature geothermal resource areas having the potential for electrical power generation. High temperature is defined to be greater than 125 degree celsius (250 degree fahrenheit) at depths less than 3 kilometers (9800 feet). These areas have been mapped and identified as potential geothermal resource areas. Also identified in the assessment process were low temperature (less than 125 degree celsius) geothermal resource areas. Further research may be directed in these areas to determine the availability of geothermal resources for future consideration in identifying potential geothermal resource areas.

The Committee has completed its work in time for initiating impact analysis by the Department of Land and Natural Resources and will continue to be available to assist the Department throughout the process of designating geothermal resource subzones.

Respectfully submitted,

Manabu Tagomori, Chairman	Donald Thomas, Technical Leader
Bill Chen	Daniel Lum
Dallas Jackson	Richard Moore
James Kauahikaua	John Sinton

ACKNOWLEDGMENT

The Geothermal Resources Technical Committee acknowledges the assistance of the individuals listed below who provided geotechnical information, participated in technical sessions, and assisted in field visits of sites by the Committee.

BILL CRADDICK	Barnwell Geothermal Corporation
ED CRADDICK	Barnwell Geothermal Corporation
MURRAY GARDNER	Geothermex, Inc.
ARDEN HENDERSON	Maui Electric Company
JOE IOVENITTI	Thermal Power Company
ALLAN KAWADA	True Geothermal Energy Co.
SAM KEALA	Campbell Estate
BOB KOYANAGI	Hawaiian Volcano Observatory
ROD MOSS	Mid-Pacific Geothermal, Inc.
GERALD NIIMI	Thermasource, Inc.
REGGIE OKAMURA	Hawaiian Volcano Observatory
C. PARDEE ERDMAN	Ulupalakua Ranch

THE GEOTHERMAL RESOURCES TECHNICAL COMMITTEE

MANABU TAGOMORI, P.E. (Chairman)
Engineer
Dept. of Land & Natural Resources
State of Hawaii

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Geochemist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

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Dept. of Computer Sciences
University of Hawaii - Hilo

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Geophysicist
Hawaiian Volcano Observatory
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U.S. Geological Survey

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Honolulu, Hawaii

JOHN SINTON, Ph. D.
Geologist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

* * * * * * * * * *

Staff
Division of Water and Land Development

DEAN NAKANO, Geologist

JOSEPH KUBACKI, Energy Specialist

PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, required that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which addresses each of the subzone designation factors. This report assesses the potential for production of geothermal energy throughout the State of Hawaii.

The Geothermal Resources Technical Committee, formed by the Department, has selected areas within the State which have the greatest potential to produce geothermal energy. The participation of the Committee members, who have volunteered their time and effort, is greatly appreciated.

This report was prepared by Dean Nakano, Geologist, with the assistance of Joseph Kubacki, Energy Specialist, and under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development, Department of Land and Natural Resources.

CONTENTS

SUMMARY

A Geothermal Resources Technical Committee was formed to assist the Department of Land and Natural Resources in locating geothermal resources for electrical power generation. Participants were selected on the basis of their expertise in the field of geothermal resources in Hawaii.

Technical Committee members met in a series of meetings held on the islands of Oahu, Maui and Hawaii to evaluate currently available geotechnical data relevant to the assessment and identification of potential geothermal resource areas.

The statewide geothermal resource assessment, as mandated by Act 296, SLH 1983, was made on a county-by-county basis and was based on a qualitative interpretation of regional surveys and available exploratory drilling data.

The Technical Committee has identified seven High Temperature and five Low Temperature Potential Geothermal Resource Areas that are listed below:

Potential Geothermal Resource Areas

High Temperature Resource Areas
(greater than 125°C at depths less than 3 km)

Area	Percent Probability
Haleakala S.W. Rift Zone, Maui	25% or less
Haleakala East Rift Zone, Maui	25% or less
Hualalai, Hawaii	35% or less
Mauna Loa S.W. Rift Zone, Hawaii	35% or less
Mauna Loa N.E. Rift Zone, Hawaii	35% or less
Kilauea S.W. Rift Zone, Hawaii	Greater than 90%
Kilauea East Rift Zone, Hawaii	Greater than 90%

Low Temperature Resource Areas
(less than 125°C at depths less than 3 km)

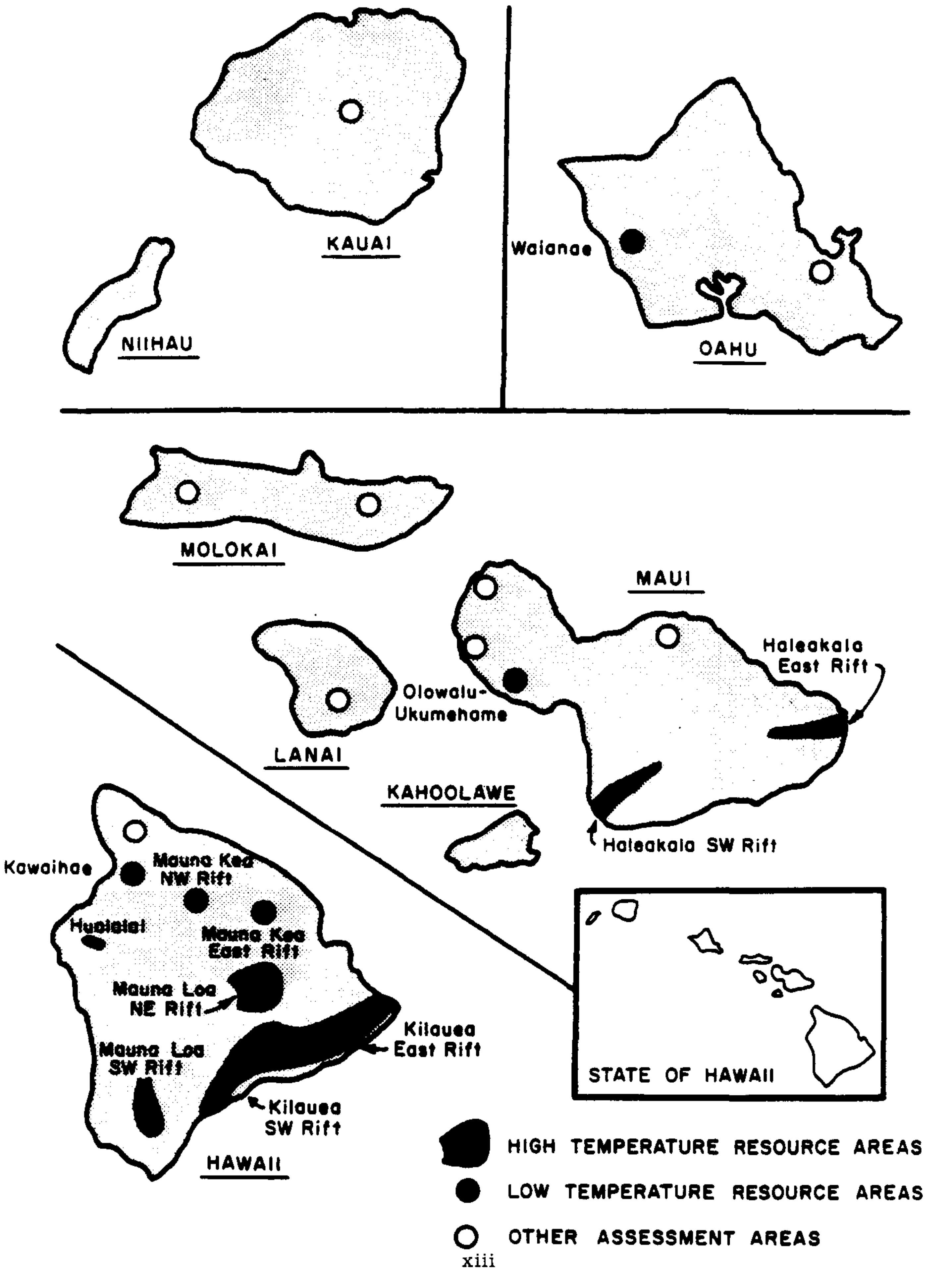
Area	Percent Probability
Waianae, Oahu	15% or less
Olowalu-Ukumehame, Maui	75% or less
Kawaihae, Hawaii	45% or less
Mauna Kea N.W. Rift Zone, Hawaii. . .	Less than 50%
Mauna Kea East Rift Zone, Hawaii . . .	Less than 30%

The selection of a high temperature resource area was based on the area's potential for production of electrical energy. The consensus of the Technical Committee was that present day technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than 3 km. Subsequent analysis of social, economic, environmental and hazards impacts will be conducted on these site specific areas.

Also identified were low temperature resource areas that have a number of feasible direct-heat applications and may warrant future research to re-evaluate their potential for high temperature electrical power generation.

These potential geothermal resource areas are identified on the following map.

STATEWIDE GEOTHERMAL RESOURCE ASSESSMENT



INTRODUCTION

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii by Act 296, SLH 1983, signed into law on June 14, 1983 by Governor George R. Ariyoshi.

The statewide geothermal resource assessment is the first phase in the process of designating geothermal resource subzones on a county-by-county basis pursuant to the Plan of Study prepared by the Department of Land and Natural Resources.

Act 296, SLH 1983 mandated that this subzone work be done by utilizing available information. Therefore, this assessment phase will focus upon current geotechnical data, its interpretation and identification of potential geothermal resources areas on all of the major islands. The initial assessment based on the estimated percent probability of geothermal resources will be mapped to conclude this phase of the designation process.

GEOTHERMAL RESOURCES TECHNICAL COMMITTEE

The Department of Land and Natural Resources has selected a committee of technical experts who are closely associated with the field of geothermal research in the State of Hawaii. This Geothermal Resources Technical Committee upon evaluation of currently available information, has identified potential geothermal resource areas on a county-by-county basis.

The members of the Geothermal Resources Technical Committee were selected on the basis of their area of expertise and their availability to assist DLNR in the evaluation of technical data relevant to the identification of potential geothermal resource areas.

It should be noted that other technical experts were considered during the committee selection process, but due to individual problems in scheduling and the projected workload increase, those contacted declined DLNR's request for assistance.

A list of the participating committee members and their area of technical expertise is described below:

Mr. Manabu Tagomori Area of expertise: Engineering
Chief Water Resources and Flood Control Engineer
Division of Water and Land Development
Department of Land and Natural Resources

Dr. Donald Thomas Area of expertise: Geochemistry
Project Leader, Direct Heat Resources Assessment Project
Hawaii Institute of Geophysics, University of Hawaii

Dr. Bill Chen Area of expertise: Reservoir engineering
Project Manager, HGP-A Wellhead Generator Project
Participated in the Hawaii Geothermal Project as
reservoir engineer.
University of Hawaii - Hilo

Mr. Dallas Jackson Area of expertise: Geology and Geophysics
Principle investigator for geoelectrical studies at HVO.
Participated in self-potential research related to geothermal
resource.
U.S. Geological Survey, Hawaiian Volcano Observatory.

Dr. James Kauahikaua Area of expertise: Geophysics
Research includes geoelectrical studies such as resistivity surveys
related to the identification of geothermal resource.
U.S. Geological Survey

Mr. Daniel Lum Area of expertise: Geology - Hydrology
Head, Geology and Hydrology Section
Division of Water and Land Development
Department of Land and Natural Resources

Dr. Richard Moore Area of expertise: Geology
Chief of "Geology and Petrology of Hualalai Volcano" project.
Research includes geological mapping and the study of geothermal
potential on Hualalai and Kilauea Volcanoes.
U.S. Geological Survey, Hawaiian Volcano Observatory.

Dr. John Sinton Area of expertise: Geology
Participated in geological mapping studies for the preliminary
State-wide Geothermal Assessment Program.
Hawaii Institute of Geophysics, University of Hawaii

A more detailed resume of each committee member can be found in Appendix C.

ASSESSMENT APPROACH AND CRITERIA

A series of committee meetings were scheduled during th Statewide Geothermal Resource assessment phase. The firs organizational meeting addressed the provisions of Act 296, th administrative rules, plan of study, and the assessment of availabl information. The committee members were asked to review th bibliography of available information to see if any significant literatur had been omitted. It was also agreed that official notice be given t all newspaper agencies inviting the public to submit any additional dat relevant to the assessment of potential geothermal resource. Subsequent committee meetings were scheduled to evaluate each island's potential for geothermal resource on a county-by-county basis. The following is a list of the Geothermal Resources Technical Committee meetings:

Date	Place
March 16, 1984	Honolulu, Hawaii
March 30, 1984	Maui, Hawaii
April 9, 1984	Honolulu, Hawaii
April 18, 19, 1984	Hilo, Hawaii
April 23, 1984	Honolulu, Hawaii
May 11, 1984	Honolulu, Hawaii
June 8, 1984	Honolulu, Hawaii

Due to the complexity of Hawaii's geologic structure and the variable nature of groundwater hydrology and geochemistry, the committee did not rely on just one set of data or a single set of rules. Therefore, the assessment of potential for each island was based on a qualitative interpretation of several regional surveys conducted in Hawaii during the last 15 to 20 years and any available deep exploratory drilling data. It was further noted that the use of probability ranges was more appropriate in assessing geothermal resource, in that probabilities would be more accurate than other subjective wording.

The committee's assessment was based on the following types of geological, geophysical and geochemical data:

1. Groundwater temperature data. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

2. Geologic age. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

3. Geochemistry. Groundwater having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered groundwater are anomalously high silica (SiO_2), chloride (Cl) and magnesium (Mg) concentrations. In addition, the evidence of above normal concentrations of trace and volatile elements such as mercury (Hg) and radon (Rn) may indicate leakage of geothermal fluids into nearby rock structures.

4. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of circulating groundwater. Therefore rocks saturated with warm saline groundwater have lower resistivities than rocks saturated with colder groundwater.

5. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above ambient ground temperatures.

6. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

7. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered, have substantially different magnetic properties than normal rock strata.

8. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

9. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

10. Self potential. Self potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea east rift.

A more in-depth description of the various types of geothermal exploration techniques can be referred to in the earlier DLNR report titled, "Assessment of Available Information Relating to Geothermal Resources in Hawaii", Circular C-98.

STATEWIDE RESOURCE ASSESSMENT

The preliminary phase in the Designation of Geothermal Resourc Subzones is the determination of Potential Geothermal Resource Area on a county-by-county basis. Upon evaluation of currently availabl geotechnical data, the Geothermal Resources Technical Committe identified the location and percent probability of finding Lo Temperature (less than 125°C) Resources and High Temperatur (greater than 125°C) Resources at depths less than 3 km.

A county-by-county listing of the areas that were evaluated and the committee's conclusions follows:

HAWAII COUNTY

Kawaihae:

On the basis of groundwater temperature and chemical anomalies and the resistivity interpretation indicating the presence of an intrusive body associated with the Puu Loa cinder cone; and taking into consideration the geologic age of this vent, the following probabilities are estimated:

- o 45% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 10% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Hualalai:

Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologically young age of vents along the upper rift and summit, the following probabilities are estimated:

- o 70% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Mauna Loa Southwest Rift:

On the basis of recent historic volcanic eruptions, seismic activity and taking into consideration the absence of any other significant geophysical or geochemical anomalies, the following probabilities are estimated:

- o 60% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It should be noted that due to the limited amount of data, additional studies are warranted in the future in order to update our current assessment.

Mauna Loa Northeast Rift:

On the basis of geochemical and geophysical data for the lower rift near the vicinity of Mountain View and Keaau, it is unlikely that a geothermal resource would be found.

While upper-elevation seismic and self potential data and the recent 1984 Mauna Loa eruption indicate a geothermal resource, it should be noted that current drilling technology limits development to elevations of less than 7,000 feet above sea level. Based on available data the following probabilities are estimated:

- o 60% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Kohala:

On the basis of the limited amount of geochemical and geophysical data, the geologic age of the Kohala volcano, and the fact that no significant anomalies were observed, the following probabilities are estimated:

- o Less than 10% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It was noted by the Committee that, due to the limited amount of information, future studies are warranted in order to update our current assessment.

Mauna Kea Volcano:

Strictly on the basis of geologic age and one groundwater temperature anomaly recorded at Waikii well No. 5239-01, the following probabilities are estimated:

Mauna Kea Northwest Rift Zone:

- o Less than 50% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 20% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Mauna Kea East Rift Zone:

- o Less than 30% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 10% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It is noted again, that due to the limited amount of available data, further studies are warranted in the future to update our current assessment.

Kilauea Southwest Rift:

On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater chemical anomalies, the following probabilities were concluded:

- o Greater than 90% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It should be noted than although the majority of the southwest rift zone is situated within the Hawaii Volcanoes National Park and is therefore off-limits to geothermal development, the potential for geothermal resource of the entire Kilauea Southwest Rift Zone was assessed by the Committee.

Kilauea East Rift:

Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. Commerically feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. Therefore, on the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, the following probability is estimated:

- Greater than 90% chance of finding a low temperature (50-125°C) and high temperature (greater than 125°C) resource at depths less than 3 km.

MAUI COUNTY

Olowalu-Ukumehame Canyon:

Based on currently available data (groundwater temperature, resistivity, magnetics, groundwater chemistry and rift zone structure) that can identify geophysical and geochemical anomalies, and taking into consideration the geologic age of West Maui, the following probabilities are estimated:

- 75% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- Less than 15% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Lahaina-Kaanapali:

Based on the absence of any positive geochemical or geophysical data indicating above ambient subsurface temperatures, the following probability was concluded:

- Less than 5% chance of finding a low (50-125°C) or high (greater than 125°C) temperature resource at depths less than 3 km.

Honolua:

Due to the limited amount of data for the Honolua area and the absence of any positive geophysical or geochemical anomalies, the following probability was concluded:

- Less than 5% chance of finding a low (50-125°C) or high (greater than 125°C) temperature resource at depths less than than 3 km.

Haleakala Southwest Rift:

On the basis of currently available data, there is no direct evidence of warm water. However, based on the historic 1790 eruption and results of deep resistivity soundings, the following probabilities were concluded:

- o 35% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o 25% or less chance of finding high a temperature (greater than 125°C) resource at depths less than 3 km.

Haleakala Northwest Rift:

Based on the absence of any significant geochemical or geophysical anomalies other than a weak resistivity anomaly, and due to the geologic age of the last eruption, the following probabilities were concluded:

- o Less than 10% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Haleakala East Rift:

The limited amount of available data did not identify any significant anomalies; however, based on the geologic age of the Hana Series lava flows, the following probabilities for the Haleakala East Rift Zone were concluded:

- o 35% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o 25% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Molokai and Lanai:

On the basis of currently available data and the absence of any positive geophysical or geochemical anomalies, the probability of a geothermal resource is as follows:

- o Less than 5% chance of finding a low (50-125°C) or high temperature (greater than 125°C) resource at depths less than 3 km.

However, additional studies are warranted in the future in order to update our current assessment.

CITY AND COUNTY OF HONOLULU

Waianae Volcano:

On the basis of geologic age and weak resistivity, groundwater temperature, and geochemical anomalies, the probabilities for a geothermal resource are estimated as follows:

- o 15% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Koolau Volcano:

Due to the geologic age of the Koolau Volcano and the absence of any significant geochemical, self potential, magnetic or resistivity anomalies, the following probabilities were concluded:

- o Less than 10% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

KAUAI COUNTY

Kauai:

On the basis of currently available information, the geologically old age of Kauai's volcanic activity and the absence of any significant geothermal related anomalies, the probabilities for a geothermal resource are as follows:

- o Less than 5% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- o Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Minutes of the Geothermal Resources Technical Committee meetings provide a more detailed analysis of the statewide assessment and can be referred to in Appendix B.

A complete list of the percent probabilities for potential High and Low Temperature Geothermal Resource Areas in the State of Hawaii is presented on a county-by-county basis below:

PERCENT PROBABILITIES
(County-by-County)

Island/Area	High Temperature (greater than 125°C at depths less than 3 km)	Low Temperature (less than 125°C at depths less than 3 km)
KAUAI	Less than 5%	Less than 5%
OAHU		
Waianae	Less than 5%	15% or less
Koolau	Less than 5%	Less than 10%
MOLOKAI	Less than 5%	Less than 5%
LANAI	Less than 5%	Less than 5%
MAUI		
Olowalu-Ukumehame	Less than 15%	75% or less
Lahaina-Kaanapali	Less than 5%	Less than 5%
Honolua	Less than 5%	Less than 5%
Haleakala S.W. Rift	25% or less	35% or less
Haleakala N.W. Rift	Less than 5%	Less than 10%
Haleakala East Rift	25% or less	35% or less
HAWAII		
Kawaihae	Less than 10%	45% or less
Hualalai	35% or less	70% or less
Mauna Loa S.W. Rift	35% or less	60% or less
Mauna Loa N.E. Rift	35% or less	60% or less
Kohala	Less than 5%	Less than 10%
Mauna Kea N.W. Rift	Less than 20%	Less than 50%
Mauna Kea East Rift	Less than 10%	Less than 30%
Kilauea S.W. Rift	Greater than 90%	Greater than 90%
Kilauea East Rift	Greater than 90%	Greater than 90%

POTENTIAL GEOTHERMAL RESOURCE AREAS

The conclusions of the Technical Committee demonstrated that no single geothermal exploration technique, except for exploratory drilling, is capable of positively identifying a subsurface geothermal system, instead it is based on several methods resulting in an estimate of geothermal potential for a given area.

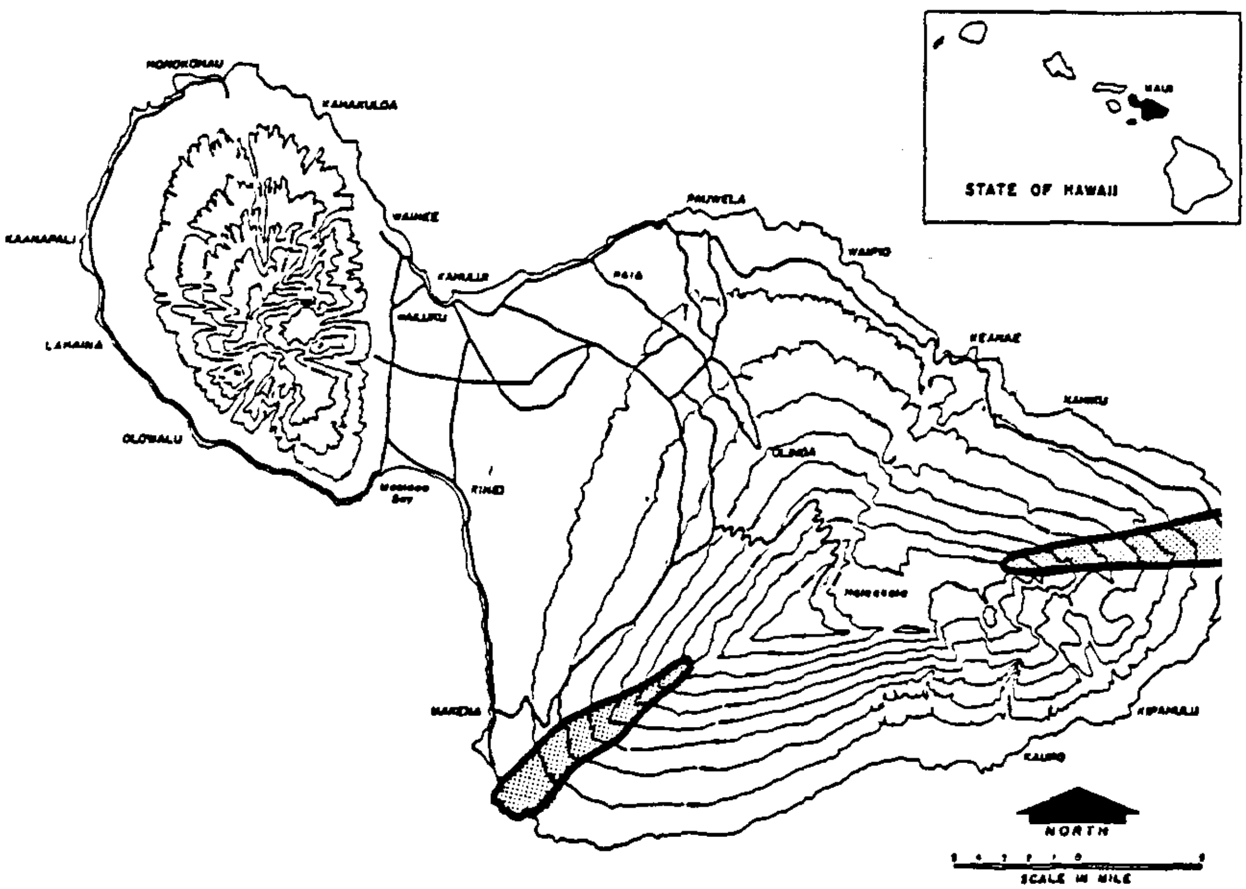
The results of the technical committee's evaluation of currently available data provides an estimate of percent probability for high temperature (greater than 125°C) and low temperature (less than 125°C) geothermal resources.

The key criterion in the preliminary subzone designation is the assessment of an area's geothermal potential for production of electrical energy, as mandated by Act 296. The consensus of the technical committee was that current technology would require the resource to have a temperature greater than 125°C at a depth of less than 3 km.

One of the most important conditions in a productive geothermal system is a permeable zone that permits adequate recharge of water to the reservoir. This criterion was not addressed during the resource assessment process, since only exploratory drilling and flow testing of deep exploratory wells can confirm the nature of the aqüifer.

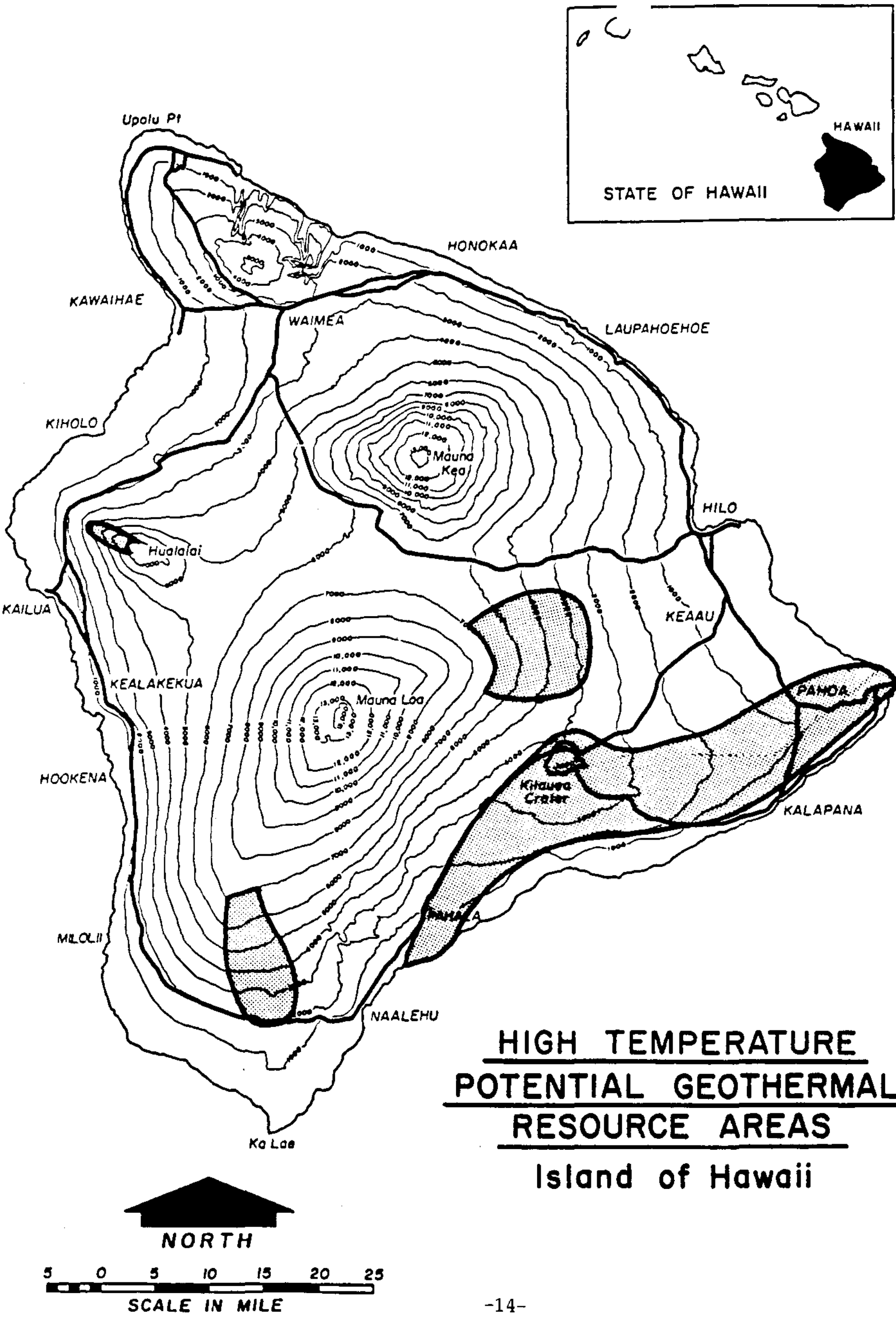
Upon evaluation of the data and review of the list of percent probabilities, the technical committee identified seven High Temperature Potential Geothermal Resource Areas. The criterion for selection of high temperature resource areas was agreed to be those areas having an assessed probability of at least 25% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Two location maps for the island of Maui and Hawaii and a list of these High Temperature Potential Geothermal Resource Areas follows:



HIGH TEMPERATURE POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Maui



HIGH TEMPERATURE POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Hawaii

High Temperature Potential Geothermal Resource Areas
(greater than 125°C at depths less than 3 km)

	Percent Probability
Maui:	
Haleakala S.W. Rift Zone	25% or less
Haleakala East Rift Zone	25% or less
Hawaii:	
Hualalai	35% or less
Mauna Loa S.W. Rift Zone	35% or less
Mauna Loa N.E. Rift Zone	35% or less
Kilauea S. W. Rift Zone	Greater than 90%
Kilauea East Rift Zone	Greater than 90%

On the basis of the committee's conclusions and the specific provision for electrical power generation set forth in Act 296, these seven High Temperature Potential Geothermal Resource Areas were identified and mapped. The technical members agreed that equal weight would be given to all positive data and the probability areas mapped would be below the 7000-foot elevation due to the limits of current drilling technology.

The use of dashed lines in identifying certain Potential Geothermal Resource Areas indicated that mapping was based on a limited amount of data. The committee could not scientifically justify using a solid line to clearly locate certain resource areas on the basis of such sparse data. The use of a solid line to draw a boundary of percent probability was restricted to those resource areas having a substantial data base upon which to make a decision as to the location of the resource.

Site location and sectional maps of Maui (scale 1"= 1 mile) and Hawaii (scale 1" = 2 miles) showing High Temperature Potential Geothermal Resource Areas and the boundary lines of percent probability are included in Appendix B (meeting No. 6).

OTHER GEOTHERMAL RESOURCE AREAS

Low Temperature Potential Geothermal Resource Areas, although not yet viable for electrical energy production based on current geothermal utilization technology, have a number of feasible direct-heat applications. Marketing opportunities for geothermal heat in the near future will be dependent upon the identification of low temperature resource areas. In addition, future site-specific surveys are warranted in these areas to re-evaluate their potential for high temperature electrical power generation.

The Geothermal Resources Technical Committee identified twelve Low Temperature Potential Geothermal Resource Areas. The basis for selection was agreed to be those areas having an assessed probability of at least 15% chance of finding a low temperature (less than 125°C) resource at depths less than 3 km. A list of five selected areas and a location map follows:

Low Temperature Potential Geothermal Resource Areas
(less than 125°C at depths less than 3 km)

Statewide	Percent Probability
Waianae, Oahu	15% or less
Olowalu-Ukumehame, Maui	75% or less
Kawaihae, Hawaii	45% or less
Mauna Kea N. W. Rift, Hawaii	Less than 50%
Mauna Kea East Rift, Hawaii	Less than 30%

Note: Not included in the list are the seven High Temperature Potential Geothermal Resource areas that also have low temperature potential.

A brief abstract of various types of direct-heat applications for geothermal energy follows:

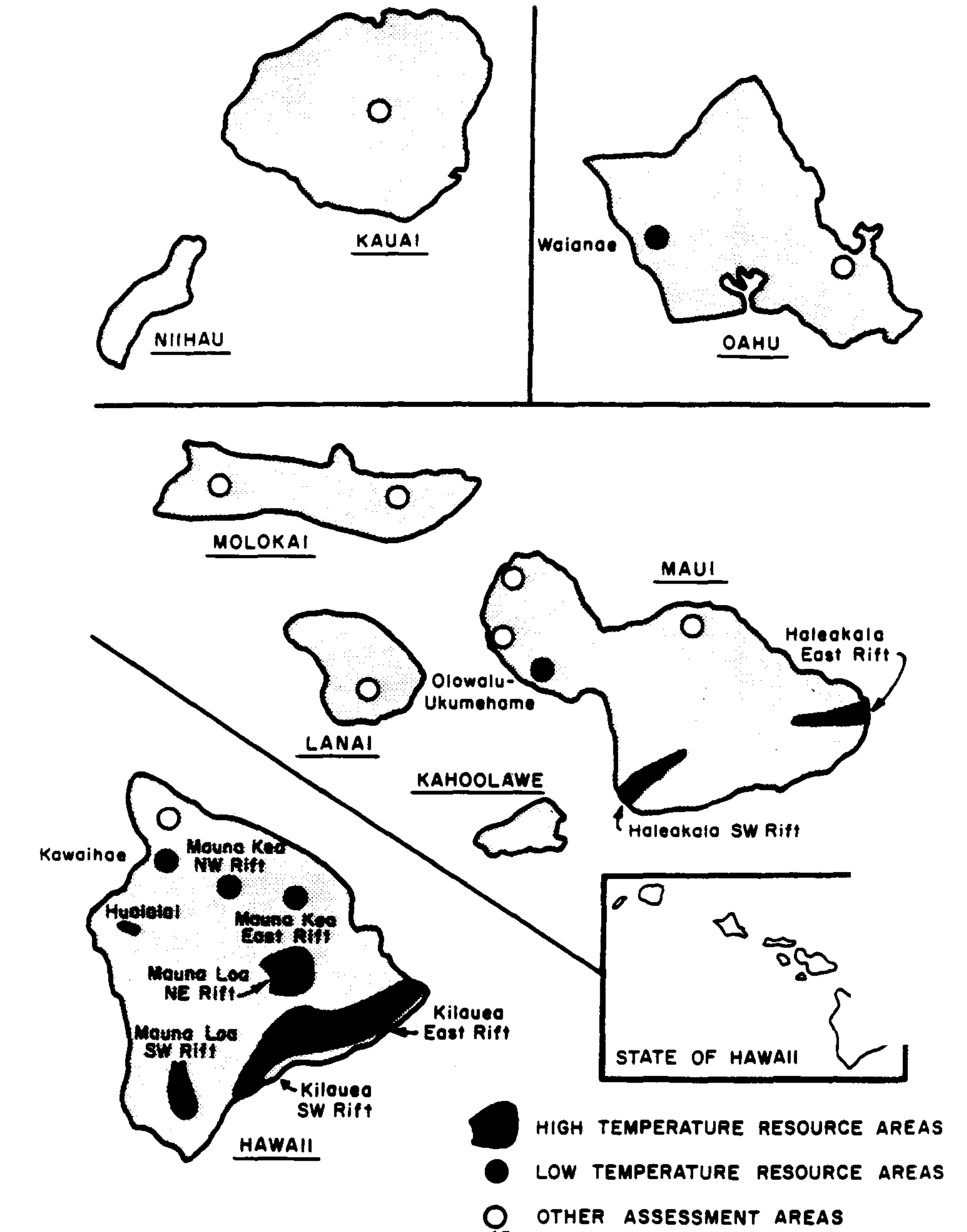
Tourism/spa:

The visitor trade may find a market for geothermal resources in the form of spas or the heating and cooling of hotel complexes.

Agriculture:

The processing of sugarcane and the heating of greenhouses and poultry operations could benefit from direct heat utilization.

STATEWIDE GEOTHERMAL RESOURCE ASSESSMENT



Food Processing:

The use of a moderate temperature resource in the processing of fruits and vegetables is another possible market in Hawaii. The food processing industry could utilize geothermal energy for the processing of macadamia nuts, coffee, guava, papaya and bananas.

Aquaculture:

Aquaculture activities can benefit from low temperature resources. Geothermal fluids can be used to maintain optimum growing temperatures for farming operations.

Existing activities that are not energy-intensive may be able to use waste heat produced during electrical power generation. Multiple applications of direct-heat may reduce some of the costs and result in a more efficient use of geothermal energy.

CONCLUSIONS

The results of the Statewide Geothermal Resource Assessment has identified several areas in the State of Hawaii that may have significant geothermal potential. Evaluation and identification of these potential geothermal resource areas were based on currently available information on geology, geophysics, geochemistry and deep exploratory drilling data.

A committee of technical experts was selected, on the basis of experience and area of expertise, to identify and provide an estimate of the percent probabilities for finding high temperature (greater than 125°C) and low temperature (less than 125°C) geothermal resources at depths less than 3 km.

The findings of the committee resulted in the identification of seven High Temperature and five Low Temperature Potential Geothermal Resource Areas. These areas and their respective percent probability are presented as follows:

Location	High Temp. Resource	Low Temp. Resource
Hawaii County:		
1) Hualalai	35% or less	70% or less
2) Mauna Loa S.W. Rift	35% or less	60% or less
3) Mauna Loa N.E. Rift	35% or less	60% or less
4) Kilauea S.W. Rift	Greater than 90%	Greater than 90%
5) Kilauea East Rift	Greater than 90%	Greater than 90%
6) Kawaihae	--	45% or less
7) Mauna Kea N.W. Rift	--	Less than 50%
8) Mauna Kea East Rift	--	Less than 30%
Maui County:		
9) Haleakala S.W. Rift	25% or less	35% or less
10) Haleakala East Rift	25% or less	35% or less
11) Olowalu-Ukumehame	--	75% or less
City and County of Honolulu:		
12) Waianae	--	15% or less

The Statewide Geothermal Resource Assessment is the first phase in the plan of study for Designating Geothermal Resource Subzones, and these first-cut subzones based solely on the availability of geothermal resources capable of electrical power generation have been mapped. Subsequent analysis of social, economic, environmental and hazards impacts will be conducted on these site specific areas having significant potential for the production of electricity from geothermal energy.

APPENDIX A

REFERENCES

REFERENCES

Abbott, A.T., 1974, Imagery from Infrared Scanning of the East and Southwest Rift Zones of Kilauea and the Lower Portion of the Southwest Rift Zone of Mauna Loa, Island of Hawaii. The Utilization of Volcano Energy, J.L. Colp and A.S. Furumoto (Eds.), pp. 10-12, Sandia Labs, Albuquerque, N.M.

Adams, W.M., A.S. Furumoto, 1965, A Seismic Refraction Study of the Koolau Volcanic Plug. Pac. Sci., Vol. 19, No. 3, p. 296.

Adams, W.M., S.P. Mathur, R.D. Huber, 1970, Aeromagnetic, Gravity, and Electrical Resistivity Exploration Between Pahala and Punaluu, Hawaii. Technical Report No. 28, Water Resources Research Center, University of Hawaii, Honolulu.

Banks, N., 1983, Personal communication.

Casadeval, T.J., R.W. Hazlett, 1983, Thermal Areas on Kilauea and Mauna Loa, Volcanoes, Hawaii. Journ. Vol. Geoth. Res., Vol. 16, pp. 173-188.

Cox, M.E., 1980, Radon Surveys for Geothermal Exploration in Hawaii. Master of Science Thesis, University of Hawaii, Honolulu.

Cox, M.E., K. Cuff, 1981a, Surface Geochemical Mapping Surveys, West Maui, Hawaii. HIG Geothermal Assessment Program, unpublished report.

_____, 1981b, Geochemical Mapping Surveys: Haiku and Makena, East Maui, Hawaii. HIG Geothermal Assessment Program, unpublished report.

_____, 1981c, Geochemical Explorations in the Kawaihae Area, Northwest Hawaii. HIG Geothermal Assessment Program, unpublished report.

_____, 1981d, Mercury and Radon Geothermal Surveys on the Western Flank of Hualalai Volcano, Hawaii. HIG Geothermal Assessment Program, unpublished report.

Cox, M.E., D.M. Thomas, 1979, Geochemical Surveys in Investigation of Geothermal Potential in the Waianae Caldera Area, Western Oahu, Hawaii. HIG Technical Report HIG-79-8.

Crandell, D.R., 1983, Potential Hazards From Future Volcanic Eruptions on the Island of Maui, Hawaii. USGS Misc. Investigation Series Map I-1442.

Diller, D.A., 1982, Contributions to the Geology of West Maui Volcano, Hawaii. Master of Science Thesis, University of Hawaii.

Druecker, M., P.F. Fan, 1976, Hydrology and Chemistry of Ground Water in Puna, Hawaii. Ground Water, Vol. 14, No. 5, pp. 340-350.

Epp, D., A.J. Halunen, Jr., 1979, Temperature Profiles in Wells on the Island of Hawaii. HIG Technical Report HIG-79-7.

Fischer, W.A., D.A. Davis, T.M. Sousa, 1966, Fresh-Water Springs of Hawaii from Infrared Images. Hydrologic Investigations Atlas, HA-218, Dept. of Interior, USGS.

Furumoto, A.S., 1976, Prospects for Geothermal Energy on the Island of Oahu, Hawaii. Geothermal Energy, Vol. 4, No. 6, pp. 7-25.

____, 1978b, Thermal Processes of Kilauea East Rift Inferred from Seismic Data, in Seismic Studies on Kilauea Volcano, Hawaii Island. HIG Technical Report, HIG-78-8, pp. 23-137.

Furumoto, A.S., J.F. Campbell, D.M. Hussong, 1970, Seismic Studies of Subsurface Structure in the Ewa Coastal Plain, Oahu, Hawaii. Pac. Sci., pp. 529-542.

Godson, R.H., C.J. Zablocki, H.A. Pierce, J.B. Frayser, C.M. Mitchell, R.A. Sneddon, 1981, Aeromagnetic Map of the Island of Hawaii. USGS Investigations Map, GP946.

Grose, L.T., 1978, Reconnaissance Geological Investigations of Geothermal Energy Potential of Kohala, Lanai, and West Molokai Volcanoes, Hawaii. A Paper submitted to George V. Keller.

Grose, L.T., G.V. Keller, 1975, Geothermal Energy in the Pacific Region Appendix A: Exploration for a Geothermal System in Lualualei Valley, Oahu, Hawaii. ONR Report, Contract No. N00014-71-A- 0430-0004.

____, 1980, Preliminary Geologic Map of Kilauea Volcano, Hawaii. USGS Open File Report, 80-796.

Holcomb, R.T., 1981, Kilauea Volcano, Hawaii: Chronology and Morphology of the Surficial Lava Flows. USGS Open File Report, 81-0354.

Hussong, D.M., D.C. Cox, 1967, Estimation of Ground-Water Configuration Near Pahala, Hawaii Using Electrical Resistivity Techniques. Technical Report No. 17, Water Resources Research Center, University of Hawaii, Honolulu.

Jackson, D.B., 1983, Personal communication.

Jackson, D.B., M.K. Sako, 1982, Self-Potential Surveys Related to Probable Geothermal Anomalies, Hualalai Volcano, Hawaii. USGS Open File Report 82-127.

Kauahikaua, J.P., M.D. Mattice, 1981, Geophysical Reconnaissance of Prospective Geothermal Areas on the Island of Hawaii Using Electrical Methods. HIG Technical Report HIG-81-4.

Kauahikaua, J.P., C.J. Zablocki, D.B. Jackson, 1979, Controlled-Source Electromagnetic Mapping at the Summit of Kilauea Volcano, Hawaii. EOS (Am. Geophys. Union, Trans.), Vol. 60, pp. 811-812.

Keller, G.V., C.K. Skokan, J.J. Skokan, J. Daniels, 1977, Electrical Resistivity and Time Domain Electromagnetic Surveys of the Puna and Kau Districts, Hawaii County, Hawaii. In Geoelectric Studies on the East Rift, Kilauea Volcano, Hawaii Island. HIG Technical Report HIG-77-15, pp. 1-90.

Kennedy, K., 1983, Personal communication.

Kinoshita, W.T., 1965, A Gravity Survey of the Island of Hawaii. Pac. Sci., Vol. 19, No. 3, p. 339.

Kinoshita, W.T., R.T. Okamura, 1965, A Gravity Survey of the Island of Maui, Hawaii. Pac. Sci., Vol. 19, No. 3, p. 341.

Klein, D.P., J.P. Kauahikaua, 1975, Geoelectric Geothermal Exploration on Hawaii Island: Preliminary Results. HIG Technical Report HIG-75-6.

Koyanagi, R.T., K. Meagher, F. W. Klein, G.S. Puniwai, J.P. Lockwood, 1978b, Hawaiian Volcano Observatory Summary 77: January to December 1977. USGS Preliminary Report.

Koyanagi, R.Y., J.S. Nakata, W.R. Tanigawa, 1981, Seismicity of the Lower East Rift Zone of Kilauea Volcano, Hawaii. USGS Open-File Report, 81-984.

Krivoy, H.L., M. Baker, E.E. Moe, 1965, A Reconnaissance Gravity Survey of the Island of Kauai, Hawaii. Pac. Sci., Vol. 19, pp. 354-358.

Kroopnick, P.M., R.W. Buddemeier, D. Thomas, L.S. Lau, D. Bills, 1978, Hydrology and Geochemistry of a Hawaiian Geothermal System: HGP-A. HIG Technical Report HIG-78-6.

Lienert, B.R., 1983, Personal communication.

Macdonald, G.A., 1975, Geology and Ground Water Hydrology in Preliminary Studies for Geothermal Exploration in Hawaii, 1973-1975. HIG Technical Report HIG-75-5, pp. 19-28.

Macdonald, G.A., A.T. Abbott, 1970, Volcanoes in the Sea. University Press of Hawaii, Honolulu.

Malahoff, A., G.P. Woollard, 1965, Magnetic Survey Over the Hawaiian Ridge. Hawaii Institute of Geophysics Technical Report 65-11.

______, 1966, Magnetic Measurements Over the Hawaiian Ridge and Their Volcanological Implications. Bull. Volcanol., Vol. 29, pp. 735-760.

Malinowski, M.J., 1977, Geology of the Kawaihae Quadrangle, Kohala Mountain, Island of Hawaii. Master of Science Thesis, University of Hawaii.

Mattice, M.D., 1981, Geothermal and Ground Water Exploration on Maui, Hawaii by Applying D.C. Electrical Soundings. Master of Science Thesis, University of Hawaii.

Mattice, M.D., A.S. Furumoto, 1978, Microearthquake Study of the Opihikao Anomaly, Puna, Hawaii. In Seismic Studies on a Kilauea Volcano, Hawaii Island, HIG Technical Report.

Mattice, M.D., J.P. Kauahikaua, 1981, Self-Potential Observations on Maui, Hawaii. Geothermal Resources Council Transactions, 1980 Annual Meeting, pp. 99-102.

Mattice, M.D., B.R. Lienert, 1980, Schlumberger Survey of Maui Island, State of Hawaii. Geothermal Resources Council Transactions, 1980 Annual Meeting, pp. 85-88.

McDougall, I., 1964, Potassium-Argon Ages from Lavas of the Hawaiian Islands. Geol. Soc. Am. Bull. Vol. 75, pp. 107-128.

McMurtry, G.M., P.F. Fan, T.B. Coplen, 1977, Chemical and Isotopic Investigations of Groundwater in Potential Geothermal Areas in Hawaii. Am. J. Sci., Vol. 277, pp. 438-458.

Moore, J.G., H.L. Krivoy, 1965, A Reconnaissance Gravity Survey of the Island of Molokai, Hawaii. Pac. Sci., Vol. 15, No. 3, p. 343.

Moore, R., 1982, Preliminary Geologic Map of the Pahoa South Quadrangle, Hawaii. USGS Open-File Report, 82-421.

______, 1983, Distribution of Differentiated Tholeiitic Basalts on the Lower East Rift Zone of Kilauea Volcano, Hawaii: A Possible Guide to Geothermal Exploration. Geology, Vol. 11, pp. 136-140.

Niimi, G., 1984, Evidence of Geothermal Potential in Kahaualea. An unpublished report prepared by Thermasource, Inc.

Porter, S.C., 1979, Quaternary Stratigraphy and Chronology of Mauna Kea, Hawaii: A 380,000 Record of Mid-Pacific Volcanism and Ice-Cap Glaciation. Summary Geol. Soc. Am. Bull., Pt. 1, Vol. 90, pp. 609-611.

Ross, H.P., 1982, A Review of Public Geophysical Data, Kilauea East Rift Area, Hawaii. Unpublished report prepared for Thermal Power Co.

Sinton, J.M., 1983, Personal communication.

Stearns, H.T., G.A. Macdonald, 1942, Geology and Groundwater Resources of Maui, Hawaii. Bull. 7, Hawaii Division of Hydrography.

Stearns, H.T., K.N. Vaksvik, 1935, Geology and Groundwater Resources of Oahu, Hawaii. Bulletin 1, Hawaii Div. of Hydrography, p. 8.

Strange, W.E., L.F. Machesky, G.P. Woollard, 1965, A Gravity Survey of the Island of Oahu, Hawaii. Pac. Sci., Vol. 24, pp. 350-353.

Suyenaga, W., M. Broyles, A.S. Furumoto, R. Norris, M.D. Mattice, 1978, Seismic Studies on Kilauea Volcano, Hawaii Island. HIG Technical Report, HIG-78-8.

Swanson, D.A., W.A. Duffield, R.S. Fiske, 1976, Displacement of South Flank of Kilauea Volcano: The Result of Foreceful Instrusion of Magma Into the Rift Zone. USGS Professional Paper 963.

Thomas, D.M., M.E. Cox, D. Erlandson, L. Kajiwara, 1979, Potential Geothermal Resources in Hawaii: A Preliminary Regional Survey. HIG Technical Report HIG-79-4.

Wright, T.L., R.S. Fiske, 1971, Origin of Differentiated and Hybrid Lavas of Kilauea Volcano, Hawaii. Journal Petrology, Vol. 12, pt. 1, pp. 1-65.

Zablocki, C.J., 1976, Mapping Thermal Anomalies on An Active Volcano by the Self-Potential Method, Kilauea, Hawaii. In Proc. of the Second U.N. Symposium on the Development and Use of Geothermal Resources, San Francisco, CA, May 1975, Vol. 2, pp. 1299-1309.

_____, 1977, Self-Potential Studies in East Puna, Hawaii. In Geoelectric Studies on the East Rift, Kilauea Volcano, Hawaii Island. HIG Technical Report HIG-77-15, pp. 175-195.

APPENDIX B

MINUTES OF TECHNICAL COMMITTEE MEETINGS

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
P. O. BOX 373
HONOLULU, HAWAII 96809

Agenda

Geothermal Resource Subzone
Technical Committee Meeting
March 16, 1984

Part I: 9:00 am to 12:00 Noon - Room 227, Kalanimoku Building
Session Leader: Manabu Tagomori

- Call to order
- Introductions
- Purpose and scope of work
- Committee meetings
- Administrative matters
- Review Plan of Study
- Review resource assessment of available information

Part II: 1:30 to 3:30 pm - HIG, University of Hawaii
Session Leader: Dr. Donald Thomas

- Geothermal Resources of Hawaii (map)
- Contribution by members
- Summary of discussions
- Directions for future meetings

MINUTES
(Amended)

Geothermal Resources Technical Committee
Meeting No. 1

Date: March 16, 1984

Time: 9:30 am - 12:00 Noon; 1:30 pm - 4:00 pm

Place: Div. of Water & Land Development Conference Room (morning); Hawaii Institute of Geophysics (afternoon).

Participants:

Manabu Tagomori, Chairman, DOWALD (548-7619)
Donald Thomas, Technical Leader, HIG (948-6482)
Dan Lum, DOWALD (548-7643)
Jim Kauahikaua, USGS-Honolulu (546-8331)
John Sinton, HIG (948-7751)
Dallas Jackson, HVO (967-7328)
Dick Moore, HVO (967-7328)
William Chen, UH-Hilo (not present)
Joe Kubacki, DOWALD (548-7466)
Dean Nakano, DOWALD (548-7541)

Agenda is attached.

Morning

Manabu Tagomori called the meeting to order and addressed all points listed in agenda. Manabu, with staff assistance, reviewed the provisions of Act 296, SLH 1983, the administrative rules; plan of study; assessment of available information; public participation program; and a report on geothermal resource developments.

Don Thomas suggested that committee members read the DOWALD assessment of available information to see if any significant literature was omitted. It was also suggested that newspaper notice be given to the public inviting them to submit any pertinent literature.

The key criteria in the preliminary subzone designation is assessing an area's geothermal potential for production of electricity. It was agreed that current technology would require the resource to have a temperature of more than 125°C at a depth of less than 3 km.

Don Thomas is to supply the committee with his latest HIG report assessing Hawaiian Geothermal resources.

Committee members may be asked to participate in a public informational meetings.

Afternoon

The meeting was reconvened by Don Thomas, the committee technical leader. Dates, locations, and topics of future meetings were scheduled.

Date	Place	Topic of Discussion
March 16 (Fri.)	Honolulu	Scope of work, administrative matters, assessment of Kauai, Oahu, Molokai, Lanai
March 30 (Fri.)	Maui	Assessment of west Maui and east Maui
April 6 (Fri.)	Honolulu	Assessment of Big Island, including Hualalai, Kawaihae, South Point, and Kilauea's SW rift zone
April 19 (Thurs)	Hawaii	Assessment of Kilauea's east rift zone
May 4 (Fri.)	Honolulu	Assessment review session

Travel and accommodations is to be arranged by Dean Nakano.

The above schedule is subject to change depending on the pace of the assessment process and other commitments of committee members.

It was suggested that the first of two public informational meetings be scheduled between April 19 and May 4, possibly April 23 or 24. Two meetings each will be held on both Maui and the Big Island.

It was agreed that the use of probability ranges was appropriate in assessing resource areas. Probabilities, though not precise, would be less ambiguous than other subjective wording. Groundwater temperatures were determined to be the most significant surface indicator of geothermal resources in most cases.

I. ASSESSMENT OF KAUAI

Groundwater Temperature. No significant data indicating above ambient temperatures.

Geologic Age. Earlier island building activity 5.6 to 3.3 million years ago (mya); post erosional activity 1.4 to 0.6 mya.

Geochemistry. Some ground water anomalies have been noted but are likely to be caused by facts other than geothermal, e.g. irrigation return.

Resistivity. No significant data.

Infrared Surveys. No significant data.

Gravity/Magnetic. Available data pertinas to identification of deep structural features (Krivoy, 1965; Malahoff and Woolard, 1965).

Seismic. No significant data.

Exploratory Drilling. No deep exploratory well data available.

Self Potential. No significant data.

KAUAI CONCLUSION:

On the basis of available data, the geologic age of Kauai's volcanic activity and the absence of any significant geothermally related anomalies, the probabilities of a geothermal resource are as follows:

- Less than 5% chance of finding low temperature (50-125°C) resource at depths less than 3 km.
- Less than 5% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

II. ASSESSMENT OF OAHU

A. Waianae Volcano

Groundwater Temperature. Weak anomaly noted at well 2808-01 where the temperature of dike impounded water is 27°C. Temperatures in nearby wells are about 19°C.

Geologic Age. The main shield building volcanism on Waianae has been dated about 2.4 million years old. Post erosional activity has occurred but no shallow magma chamber is associated with the Waianae Volcano.

Geochemistry. Some anomalous concentrations of sulfate and calcium at well 2808-01. Radon and mercury anomalies give some indication of fracture zones.

Resistivity. Some low resistivity anomalies, but inconclusive as to presence of geothermal resource.

Infrared Surveys. No significant data.

Seismic. Some seismic studies considered (Furumoto, 1970) but inconclusive as to presence of geothermal resource.

Gravity/Magnetic. Available data pertains to the identification of deep structural features (Malahoff, 1965; Strange, et al, 1965).

Exploratory Drilling. Reference is made to 3 deep wells (800 ft., 1000 ft. and 1200 ft. depths) but no significant data is available (Macdonald and Abbott, 1970; Stearns, 1935).

Self Potential. Available data has no positive indications of geothermal resource (Grose and Keller, 1975).

B. Koolau Volcano

Groundwater Temperature. Slight temperature anomalies noted in 2 wells. Well No. 2043-01 (30°C) and Well No. 2042-05 (30°C).

Geologic Age. Post-erosional volcanism occurred until possibly 30,000 years ago.

Geochemistry. Available data has no positive indications of geothermal resource.

Resistivity. Available data has no positive indications of geothermal resource.

Infrared Surveys. No significant data.

Seismic. Data suggests that the Koolau magma chamber is relatively shallow, being about 1.6 km below the surface (Adams and Furumoto, 1965) (Furumoto, 1976).

Magnetic. Available data pertains to deep structures (Malahoff, 1965).

Gravity. Provides depth estimate to Koolau plug of 1.5 to 2 km (Strange et al., 1965).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. Available data has no positive indications of geothermal resource.

OAHU CONCLUSION:

WAIANAE VOLCANO

On the basis of geologic age and some resistivity, groundwater temperature and geochemical anomalies, the probabilities for a geothermal resource are as follows:

- 15% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- Less than 5% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

KOOLAU VOLCANO

Due to the geologic age and the absence of any significant geochemical, self potential, magnetic or resistivity anomalies, the following probabilities have been concluded:

- Less than 10% chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- Less than 5% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

III. ASSESSMENT OF MOLOKAI AND LANAI

Groundwater Temperature.

West Molokai - Reported but unconfirmed anomaly in Well No. 1011-01 having a temperature of 30-33°C. Well presently is collapsed.

East Molokai and Lanai - Available data has no positive indications of geothermal resource.

Geologic Age.

West Molokai - About 8 million years old.

East Molokai - About 1.5 to 1.3 million years old, with post erosional activity at Kalaupapa Peninsula about 400,000 years ago.

Lanai - About 1.6 to 1.8 million years old.

Geochemistry.

Molokai - Some weak ground water chemistry anomalies but probably due to irrigation water return or soil types.

Lanai - Available data has no positive indications of geothermal resource.

Resistivity. No significant data.

Infrared. No data available.

Seismic. No data available.

Gravity/Magnetic. Available data pertains to identification of deep structural features. The central caldera and rift systems of West Molokai are well defined by gravity highs, with marginal coverage over the eastern end of the island (Moore and Krivoy, 1965; Malahoff, 1976).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. No data available.

MOLOKAI AND LANAI CONCLUSION:

On the basis of available data and the absence of any positive geophysical or geochemical anomalies the probability for a geothermal resource is as follows:

- Less than 5% chance of finding a low (50-125°) or high (greater than 125°)temperature resource at depths less than 3 km. It should be noted that due to the limited data, future studies are warranted in order to update our current assessment.

Recommended references for Maui:

Diller Thesis
Brill
Horton
Kennedy
Lienert
Mattice Thesis
Sinton Maps
HVO records for Maui Seismometer
Crandell Map

JOSEPH KUBACKI

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

Agenda

Geothermal Resources Technical Committee
Meeting No. 2

March 30, 1984
Maui Electric Company
210 Kamehameha Avenue
Kahului, Maui

9:00 am to 12:00 N -

- Call to order: Dan Lum
- Remarks by Arden Henderson, Maui Electric Co.
- Approval of minutes

Session Leader: Donald Thomas

- Review Conclusions on Kauai, Oahu, Molokai, and Lanai
- Assessment of Geothermal Resources on Maui
  - * West Maui
  - * East Maui, generally
  - * Haleakala S.W. Rift Zone
- Review key references for Hawaii

12:00 N to 12:30 pm -

- Lunch and 15 minute geothermal video presentation by Maui Electric Co.

2:00 pm to 2:30 pm -

- Presentation by R.B. Moss, Mid-Pacific Geothermal, Inc. and Allan Kawada, True Geothermal Energy Co.

2:30 pm to 4:30 pm -

- Field trip to Haleakala South West Rift Zone (Ulupalakua Ranch, Maui Electric Company, Mid-Pacific Geothermal, Inc., Technical Comm.) Field trip leader: R.B. Moss

4:30 pm -

- Adjournment

MINUTES
(Amended)

Geothermal Resources Technical Committee
Meeting No. 2

Date: March 30, 1984

Time: 9:00 am - 2:00 pm; 2:30 pm - 4:30 pm

Place: Maui Electric Co. Conference Room (morning)
Ulupalakua Ranch (afternoon)

Participants: Dan Lum, DOWALD
Donald Thomas, HIG
Jim Kauahikaua, USGS
John Sinton, HIG
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Morning

Meeting called to order by Dan Lum, followed by opening remarks from Arden Henderson of Maui Electric Co. who reported briefly on the importance of geothermal development on Maui. Mr. Henderson stressed the desire for electrical production from geothermal energy rather than fossil fuel, thereby reducing Hawaii's dependence on imported oil and creating less pollution in the environment. Maui Electric Co.'s present electrical output is 96 megawatts and the initial goal at the proposed Ulupalakua Ranch site would be 13 megawatts with a maximum production set at 50 megawatts.

A 15-minute video film presentation produced by Maui Electric Co. was viewed by the members of the technical committee. The video briefly described geothermal development and interviewed various members of the community and government officials whose general consensus was in favor of geothermal energy as an alternate resource.

The minutes of the March 16, 1984 meeting and the Committee's conclusions on Kauai, Oahu, Molokai and Lanai were revised and approved by the Technical Committee.

The next meeting was tentatively scheduled for April 6, 1984 at 9:00 am in the HIG conference room in Honolulu.

The meeting was turned over to Don Thomas who divided the assessment of Maui into six (6) general locations:

West Maui: (Olowalu-Ukumehame, Lahaina, Honolua); and

East Maui: (Haleakala S.W. Rift Zone, Haleakala East Rift, Haleakala N.W. Rift Zone)

Based upon the available information, the following assessment and probability ranges were concluded by the Technical Committee:

I. ASSESSMENT OF WEST MAUI

A. OLOWALU-UKUMEHAME CANYON

Groundwater Temperature. Confirmed low temperature anomalies noted in two wells: Well No. 4937-01 (25.6°C) and Well No. 4835-01 (35°C).

Geologic Age. The main shield building volcanism on West Maui has been dated between 1.15 to 1.30 million years ago (mya) and some post erosional activity has occurred. Data indicates that the southeast rift migrated from a southeasterly strike to a southwesterly strike. Structural features such as dikes, plugs and vents have been identified within the canyon (Macdonald and Abbott, 1970; McDougall, 1964; Diller, 1982; Stearns, 1942).

Geochemistry. Some minor mercury and radon anomalies noted, but unable to make any firm conclusions due to the limited amount of data (Cox and Cuff, 1981). Some anamolous calcium and sulfate concentrations recorded at well No. 4937-01. Recent water samples confirmed silica and chloride/magnesium ratio anomalies possibly indicating thermal alteration. Spring and stream water samples indicate a difference in groundwater chemistry between those taken near the back of Olowalu Canyon and those found at the mouth of Ukumehame Canyon. It should be noted that tritium levels (Kennedy, 1983) indicate rapid circulation of above ambient groundwater, possibly indicating a shallow, low temperature resource.

Resistivity. Schlumberger surveys indicate an anomalous layer of seawater having low resistivity. This anomalous resistivity layer (approximately 4.3 ohm-m) has been estimated to be up to 500 m thick and located 80-200 m below sea level. Based on 20% porosity, fluid temperature has been estimated at 90°C (Mattice, 1981; Mattice and Lienert, 1980).

Infrared Surveys. No available data.

Seismic. No significant data.

Magnetic. Available data pertains to the identification of deep structural features. A magnetic anomaly identified an intrusive body in the canyon, possibly indicating a reversal of polarity or temperatures above the Curie point (543°C) (Malahoff and Woolard, 1965; Lienert, 1983).

Gravity. Available data has no positive indications of geothermal resource (Kinoshita and Okamura, 1965).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. Available data has no positive indications of geothermal resource (Kauahikaua and Mattice, 1981).

Conclusion:

Based on available data (groundwater temperature, resistivity, magnetics, groundwater chemistry and rift zone structure) that identify geophysical and geochemical anomalies and taking into consideration the geologic age of West Maui, the following probabilities were concluded:

- 75% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.
- Less than 15% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

B. LAHAINA-KAANAPALI

Groundwater Temperature. Weak groundwater temperature anomalies noted in 3 wells: Well No. 5240-01 (26.82°C); Well No. 5240-03 (24.93°C); and Well No. 5340-01 (25.20°C).

Geologic Age. Lahaina-Kaanapali area located to the northwest of Olowalu Canyon. Two post erosional vents have been identified (Puu Laina and Kekaa Point) but there does not appear to be any relationship between these vents and the West Maui Rift Zones (Macdonald and Abbott, 1970; Diller, 1982).

Geochemistry. Available data has no positive indications of geothermal resource. Results of mercury and radon survey similar to Olowalu-Ukumehame, indicated few minor anomalies, but unable to draw any firm conclusions (Cox and Cuff, 1981).

Resistivity. Schlumberger survey data available but no positive indications of geothermal resource (Mattice, 1981; Mattice and Lienert, 1980).

Infrared Surveys. No available data.

Seismic. No significant data.

Magnetic. Available data pertains to the identification of deep structural features (Malahoff and Woolard, 1965).

Gravity. Available data has no positive indications (Kinoshita and Okamura, 1965; Malahoff and Woolard, 1965).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. Available data has no positive indications of geothermal resource (Kauahikaua and Mattice, 1981).

Conclusion:

Based on the absence of any positive geochemical or geophysical data indicating above ambient subsurface temperatures, the following probability was concluded:

- Less than 5% chance of finding a low (50-125°C) or high (greater than 125°C) temperature resource at depths less than 3 km.

C. HONOLUA

Groundwater Temperature. Available data does not report any groundwater temperature anomalies.

Geologic Age. Although Honolua is located near the northwest rift zone, no post erosional activity has been recorded (Macdonald and Abbott, 1970).

Geochemistry. No significant groundwater chemistry anomalies (Thomas et al, 1979).

Resistivity. Schlumberger survey data report no significant resistivity anomalies (Mattice, 1981).

Infrared Surveys. No data available.

Seismic. No data available.

Magnetic. Available data pertains to the identification of deep structural features (Malahoff and Woolard, 1965).

Gravity. Available data has no positive indications (Kinoshita and Okamura, 1965; Malahoff and Woolard, 1966).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. No data available.

Conclusion:

Based on the absence of any positive geophysical or geochemical anomalies, the following probability was concluded:

- Less than 5% chance of finding a low (50-125°C) or high (greater than 125°C) temperature resource at depths less than 3 km.

II. ASSESSMENT OF EAST MAUI

A. HALEAKALA SOUTHWEST RIFT ZONE

Groundwater Temperature. All wells sampled were located outside of the rift zone and many of these wells tapped into perched aquifers rather than the local basal lens. Available data indicates no significant groundwater temperature anomalies.

Geologic Age. Haleakala is the younger and larger of the two volcanoes that formed the island of Maui. Three eruptive phases have been identified: The Honomanu Phase (approximately 750,000 years ago); the Kula Series (approximately 500,000-600,000 years ago); and more recently the Hana Series that began about 70,000 years ago. Six to seven eruptions have occurred on the S.W. Rift within the last 1000 years and the lava's crystal formation suggests that these flows came from a magma chamber at moderate depth. The most recent post erosional eruption occurred in 1790 on the lower S.W. Rift of Haleakala from 2 vents located at elevations 155 m and 472 m above sea level (Macdonald and Abbott, 1970; Crandell, 1983; Sinton, 1983).

Geochemistry. Soil mercury and radon emanometry surveys identified some anomalies, but due to wide variations in soil and rock types no definite conclusions could be drawn (Cox and Cuff, 1981).

Resistivity. Schlumberger surveys indicated high resistivities and yielded little information regarding thermal conditions (Mattice, 1981). Electromagnetic soundings indicated moderate to low resistivity (6 to 7 ohm-m) to depths of 1 Km on the lower rift zone and higher resistivities (12 to 16 ohm-m) beneath the upper rift zone (Lienert, 1983). Subsurface temperature has been estimated at 57°C based on 20% porosity within 500-800 meters below sea level.

Infrared Surveys. No available data.

Seismic. No significant data having positive indications of geothermal resource.

Gravity/Magnetic. Available data pertains to the identification of the rift zone (Kinoshita and Okamura, 1965; Malahoff and Woolard, 1966).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. Available data has no positive indications of geothermal resource (Mattice and Kauahikaua, 1981).

Conclusion:

On the basis of available data, there is no direct evidence of warm water. However, due to the young geologic age of the recent 1790 eruption and the results of the deep resistivity soundings, the following probabilities have been concluded:

- 35% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- 25% or less chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

B. HALEAKALA NORTHWEST RIFT ZONE

Groundwater Temperature. Water temperatures ranged from 21°C to 24°C but are related to perched ash bed aquifers rather than basal ground water.

Geologic Age. Some Kula Series vents (about 500,000 years old) have been located on the lower N.W. Rift, but no Hana Series vents have been identified (Macdonald and Abbott, 1970; McDougall, 1964).

Geochemistry. Soil mercury and radon emanometry surveys indicated above ambient levels but may be due to wide variation in soil and rock type. Groundwater chemistry anomalies are related to perched ash bed aquifers rather than basal ground water (Cox and Cuff, 1981).

Resistivity. Schlumberger soundings indicated a weak resistivity anomaly at a depth of about 20 meters (Mattice and Lienert, 1980; Mattice, 1981).

Infrared Survey. No available data.

Seismic. No available data.

Gravity/Magnetics. Available data pertains to the identification of the rift zone (Kinoshita and Okamura, 1965; Malahoff and Woolard, 1965).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. Available data has no positive indications of geothermal resource (Mattice and Kauahikaua, 1981).

Conclusion:

Based on the absence of any geochemical or geophysical anomalies other than a weak resistivity anomaly and due to the geologic age of the last eruption, the following probabilities were concluded:

- Less than 10% chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- Less than 5% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

C. HALEAKALA EAST RIFT ZONE

Groundwater Temperature. Water temperatures ranged from 18.5°C to 20.2°C, well within the normal range.

Geologic Age. The East Rift Zone has had recent (Kula and Hana Series) volcanism similar to the S.W. Rift Zone. Lava has been dated between 490 to 10,000 years ago (Crandell, 1983; Macdonald and Abbott, 1970).

Geochemistry. Some data indicated chloride/magnesium and sulfate anomalies, but these wells are reportedly not pumped on a regular basis; therefore, no positive indications can be confirmed.

Resistivity. Available data has no positive indications of geothermal resource (Mattice, 1981; Mattice and Kauahikaua, 1981).

Infrared Surveys. No available data.

Seismic. No available data.

Gravity/Magnetics. Available data pertains to identification of the rift zone (Kinoshita and Okamura, 1965; Malahoff and Woolard, 1966).

Exploratory Drilling. No deep exploratory well data available.

Self Potential. No available data.

Conclusion.

Taking into consideration the limited amount of available data and based solely on the geologic age of the Hana Series lava flows, the following probabilities for the Haleakala East Rift Zone were concluded:

- 35% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.
- 25% or less chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

Afternoon

Rod Moss from Mid-Pacific Geothermal, Inc. and Allan Kawada from True Geothermal Energy Co. gave a short presentation on their proposed geothermal venture on Ulupalakua Ranch lands. Although no new technical data was submitted, Mr. Moss indicated that the Maui area being considered is along the S.W. rift zone; identified (Crandell, 1983) as having the most potential for volcanic activity on dormant Haleakala. A leasing agreement has been reached between Ulupalakua Ranch and True/Mid-Pacific. It was also noted that other areas on East Maui (Haleakala N.W. rift and Haleakala East Rift) had been seriously considered, but failed to materialize due to the problems associated with the leasing of contiguous land.

During our afternoon field trip, the Technical Committee was able to view the proposed drilling sites on Ulupalakua Ranch, running from about the 6,000-foot elevation down to about a mile and a half from Cape Kinau. Mr. Moss emphasized the availability of land, the limited number of residents and indicated that the nearest populated spot was Kainao Homesteads.

Upon completion of the field trip the meeting was adjourned at 4:30 pm.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

AGENDA

Geothermal Resources Technical Committee
Meeting No. 3

April 9, 1984
Hawaii Institute of Geophysics
(Conference Room)
University of Hawaii
Honolulu, Hawaii

9:00 am Call to Order: Manabu Tagomori

- Approval of minutes (to be circulated at the meeting)

Technical Session Leader: Donald Thomas

- Review Conclusions on Maui
- Assessment of geothermal resources on Hawaii, generally

12:00 noon - Lunch

1:00 pm Continue morning session

- Review key references for Kilauea East Rift Zone
- Review future meeting schedule

3:00 pm Adjournment

MINUTES
(Amended)

Geothermal Resources Technical Committee
Meeting No. 3

Date: April 9, 1984

Time: 9:00 am - 12:00 Noon; 1:30 pm - 3:30 pm

Place: HIG Conference Room, University of Hawaii

Participants: Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
Dan Lum, DOWALD
John Sinton, HIG
Dallas Jackson, HVO
Richard Moore, HVO
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Morning Session

Manabu Tagomori called the meeting to order and thanked all of the Technical Committee members for their continued assistance in this assessment program. The Committee was informed that the administrative rules have been approved by the Governor and is to be reviewed by the Land Board on Friday, April 13, 1984, and scheduled for public hearings in all counties on May 22, 1984.

Public participation and information meetings have been tentatively set for May 1 and 2, 1984 at Kihei and Puna, respectively and again on May 30 and 31, 1984.

Copies of the approved minutes for the March 16, 1984 meeting along with minutes of the March 30, 1984 meeting were distributed to the committee. The minutes of the last meeting and the committee's conclusions on Maui were briefly reviewed and discussed. Although there were no major objections to the conclusions drawn, it was suggested that approval of the minutes be deferred to later, subject to any revisions that the committee may recommend.

It was noted and approved that the subheading titled Honokawai should be more accurately labeled as Honolua rather than Honokawai.

The meeting was turned over to Don Thomas who divided the evaluation of Hawaii into nine general locations. Based upon the assessment of available information, the following probability ranges were concluded by the Technical Committee:

ASSESSMENT OF THE ISLAND OF HAWAII

A. KAWAIHAE

Groundwater Temperature. Groundwater temperature anomalies were noted in 4 wells: Well No. 6048-02 (26°C), Well No. 5745-01 (26°C), Well No. 5745-02 (26.5°C), and Kawaihae 3, Well No. 6147-01 (37°C), which is clearly above ambient temperature.

Geologic Age. The limited data available indicates that the most recent post erosional activity (Hawi Volcanic Series) occurred at Puu Loa and has been estimated at about 80,000 years ago. Kawaihae is located on the saddle between the Mauna Kea and Kohala volcanoes and is not situated within a recently active rift zone (Macdonald and Abbott, 1970; Malinowski, 1977).

Geochemistry. Available soil mercury and radon emanometry data show no positive geothermal indications. Some minor anomalies were noted but did not lead to any firm conclusions (Cox and Cuff, 1981). Well No. 6147-01 indicated an anomalous chloride/magnesium ratio and several other wells had slight chemical variations.

Resistivity. Schlumberger soundings did not identify any low resistivity anomalies indicating geothermal resource. High basement resistivities recorded were interpreted to indicate a dense intrusive body (Kauahikaua and Mattice, 1981).

Infrared Surveys. No thermal anomalies were noted having any positive geothermal indications (Fischer, et al, 1966).

Seismic. Data indicates that earthquakes of magnitudes greater than 4.0 have occurred near Kawaihae at least once a year. Earthquakes have been scattered without any significant cluster recorded, therefore no positive indications.

Magnetic. Aeromagnetic survey indicated an anomaly between Waimea and Kawaihae Bay and has been interpreted to correspond to an intrusive body rather than a Curie point temperature (Malahoff and Woolard, 1965; Godson, et al, 1981).

Gravity. No positive indications; data pertains to the identification of deep structural features (Kinoshita, 1965).

Exploratory Drilling. No deep exploratory well data.

Self Potential. No available data.

Conclusion:

On the basis of groundwater temperature, chemical anomalies and the resistivity interpretation indicating the presence of an intrusive body associated with the Puu Loa cinder cone and taking into consideration the geologic age of this vent, the following probabilities have been concluded:

- 45% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- Less than 10% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

B. HUALALAI SUMMIT AND UPPER FLANK (above 4000-foot elevation)

Groundwater Temperature. No available data.

Geologic Age. Hualalai is situated to the northwest of Mauna Loa and is considered to be in a mature post-caldera stage of activity. Twelve to 15 vents have been identified that have erupted within the last 1,000 years, with the youngest vent being less than 200 years old. Volcanic activity along the north trending rift near Puu Waawaa last occurred about 2,000 years ago (Macdonald and Abbott, 1970; Moore, 1983).

Geochemistry. Available data indicates that hydrothermal activity has occurred due to evidence of copper sulfide and potassium metasomatism.

Resistivity. Schlumberger soundings indicate a low resistivity layer at a depth of about 480 meters which has been interpreted as a perched body of possibly warm water (Kauahikaua and Mattice, 1981).

Infrared Survey. No available data.

Seismic. There has been no concentration of any seismic activity at the summit, therefore no significant conclusions could be drawn.

Magnetics. Aeromagnetic data indicates a magnetic low near the summit that appears to be reversed. This low could be attributed to hydrothermal alteration of intrusive material or to a residual magma body above the Curie point (greater than 543°C), (Malahoff and Woollard, 1965; Godson, et al, 1981).

Gravity. No significant data.

Exploratory Drilling. No deep exploratory well data.

Self Potential. Self potential surveys indicate an anomaly across the summit and along the upper northwest rift and could possibly be due to a high temperature intrusive or dike impounded water (Jackson and Sako, 1982; Jackson, 1983).

Conclusion:

Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologically young age of vents along the upper rift and summit, the following probabilities were concluded:

- 70% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- 35% or less chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

C. HUALALAI LOWER FLANK (Below 4000-foot elevation)

Groundwater Temperature. No groundwater anomalies recorded indicating above ambient temperatures. One of the two deep wells at Puu Waawaa, Well No. 4650-01, did indicate above ambient temperature at the bottom of the well (87.6°F, bottom hole temperature).

Geologic Age. Same as Hualalai summit and upper flank. Several vents have been identified that have erupted within the last 1,000 years, the most recent eruption occurring in 1801 (Macdonald and Abbott, 1970; Moore, 1983).

Geochemistry. Soil mercury and radon emanometry surveys identified some anomalies but due to variations in soil type, no definite conclusions could be drawn (Cox and Cuff, 1981).

Resistivity. Schlumberger and time domain electromagnetic soundings were conducted but had no positive indications within 2 km depth (Kauahikaua and Mattice, 1981).

Infrared Survey. Some anomalous coastal water temperatures were reported but have not been confirmed (Fischer, et al, 1966).

Seismic. There has been a concentration of seismic activity along the rift zone near the coast and extends seaward. A recorded 1929 seismic swarm (Macdonald and Abbott, 1970) on the north flank indicated that an intrusive event had occurred, possibly suggesting that Hualalai still be considered active.

Magnetics. Available data shows no positive indications of geothermal resource and pertains to identification of deep structural features (Malahoff and Woollard, 1965; Godson, et al, 1981).

Gravity. No significant data.

Exploratory Drilling. Two deep wells near Puu Waawaa located north of the rift zone (Well No. 4850-01 and Well No. 4650-01). Only Well No. 4650-01 indicated above ambient temperature (87.6°F) at a bottom hole depth of 5,555 feet.

Self Potential. Data from lower elevation self potential surveys did not show any positive indications due to interference from buried conductive objects (Jackson and Sako, 1982; Jackson, 1983).

Conclusion:

Based on the absence of any positive geochemical or geophysical data other than a recorded concentration of seismic activity, it was concluded that the Hualalai lower flank should have a probability lower than the summit region. The Committee agreed that the assignment of a probability percentage would be deferred to later.

D. Mauna Loa Southwest Rift - South Point

Groundwater Temperature. No available data.

Geologic Age. Mauna Loa is the second most active volcano on Hawaii and has erupted during historic time: first recorded in 1868 and most recently in 1950. The 1950 eruption on the southwest rift produced the largest volume of lava (600 million cubic yds.) within the last 1,000 years. All volcanic activity has been situated on the upper rift above the 3000-foot elevation (Macdonald and Abbott, 1970).

Geochemistry. No available data.

Resistivity. Schlumberger and time domain electromagnetic surveys did not detect any significant anomalies. Data suggests that soundings did not penetrate deep enough to the basal water table, but instead terminated in unsaturated basalts (Kauahikaua and Mattice, 1981).

Infrared Survey. No conclusive data indicating geothermal resource, thermal anomaly could be attributed to solar heating of the surface rocks.

Seismic. Data indicates a concentration of seismic activity on the upper southwest rift zone above the 10,000-foot elevation.

Magnetics. Aeromagnetic surveys were flown parallel to the rift zone and therefore were not effective in showing any indications of geothermal resource (Malahoff and Woollard, 1965; Godson, et al, 1981).

Gravity. No significant data other than identification of the rift zone (Kinoshita, 1965).

Exploratory Drilling. No deep exploratory well data.

Self Potential. A negatively polarized anomaly was interpreted as the result of a downward streaming potential, rather than a geothermal heat source that would have a positively polarized self potential anomaly (Kauahikaua and Mattice, 1981).

Conclusion:

On the basis of historic volcanic eruptions, seismic activity and consideration given to the absence of other geophysical or geochemical anomalies, the following probabilities were concluded:

- 60% or less chance of finding low temperature (50-125°C) resource at depths less than 3 km.

- 35% or less chance of finding high temperature (greater than 125°C) resource at depths less than 3 km.

It should be noted that due to the limited amount of data, future studies are warranted in order to update our current assessment.

E. MAUNA LOA NORTHEAST RIFT - KEAAU

Groundwater Temperature. Available data did not indicate any significant temperature anomalies in either the upper, middle, or lower rift.

Geologic Age. The Northeast Rift Zone can be traced by vents or lava flows down to an elevation of about 600 to 900 feet above sea level. The upper northeast rift (above the 6,000-foot elevation) is currently erupting at the 9,000-foot level. Along the middle rift, (4,500 to 6,000-foot elevation) near Kulani prison, a recent vent has been dated at about 800 years old. No eruptions have occurred on the lower rift (below the 4,500-foot elevation) during historic time (Macdonald and Abbott, 1970).

Geochemistry. Soil mercury and radon emanometry surveys and groundwater chemistry data do not indicate any geothermal anomalies.

Resistivity. Resistivity data for the lower rift did not identify any geothermal anomalies. No data available for the upper or middle rift zones (Kauahikaua and Mattice, 1981).

Infrared Survey. No available data.

Seismic. A high concentration of seismic activity has been recorded in the upper and middle northeast rift. There is no significant concentration of similar activity noted in the lower rift zone.

Magnetics. Aeromagnetic data indicates a clear anomaly on the upper rift zone (Godson, et al, 1981).

Gravity. Data does not indicate any significant anomalies on the rift zone (Kinoshita, 1965).

Exploratory Drilling. No deep exploratory well data.

Self Potential. Definite anomaly recorded near site of current eruption but no significant anomalies identified on the lower northeast rift (Jackson, 1983).

Conclusion:

On the basis of geochemical and geophysical data for the lower rift near the vicinity of Mountain View and Keaau, it is unlikely that a geothermal resource would be found.

While upper-elevation seismic and self potential data and the current Mauna Loa eruption indicate a geothermal resource, it should be noted that current drilling technology limits development to elevations of less than 7,000 feet above sea level. Therefore, based on available data the following probabilities were concluded:

Mauna Loa upper northeast rift -

- Less than 90% chance of finding a low (50-125°C) or high (greater than 125°C) temperature resource at depths less than 3 km.

Mauna Loa middle northeast rift -

- 60% or less chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Mauna Loa lower northeast rift -

- Less than 5% chance of finding a low temperature (50-125°C) or high temperature (greater than 125°C) resource at depths less than 3 km.

F. KILAUEA SOUTHWEST RIFT

Groundwater Temperature. A temperature of about 32°C has been reported at a coastal spring at Wai Welawela (Casadevall and Hazlett, 1983).

Geologic Age. Kilauea is the youngest and most active volcano in Hawaii. The Southwest Rift Zone is considered active and has been the site of historic eruptions in 1823 at the 250 to 1700-foot elevation and in 1920 at the 3,000-foot elevation. The presence of steaming ground also indicates substantial geothermal potential on the Southwest Rift Zone (Macdonald and Abbott, 1970; Banks, 1983).

Geochemistry. No significant data.

Resistivity. Schlumberger, di-pole/di-pole and time domain surveys indicate resistivity anomalies on both the upper and lower rift (Hussong and Cox, 1967; Adams, et al, 1970; Keller, et al, 1977; Klein and Kauahikaua, 1975; Kauahikaua and Mattice, 1981).

Infrared Survey. No anomalies were detected, but steaming ground evident since 1971 near Mauna Iki above the 2,500-foot elevation (Fischer, et al, 1966).

Seismic. Seismic activity recorded along the southwest rift follows the gravity high indicating a southward trending rift.

Magnetics. Aeromagnetic data shows no significant anomaly and only a weak expression of the rift zone (Godson, et al, 1981; Malahoff and Woollard, 1965).

Gravity. Gravity highs identify the rift zone and its extension seaward (Kinoshita, 1965).

Exploratory Drilling. No deep exploratory well data.

Self Potential. Strong anomalies noted along the upper rift down to about the 2,000-foot elevation near Yellow Cone (Jackson, 1983).

Conclusion:

On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater temperature or chemical anomalies, the following probabilities were concluded:

- Greater than 90% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- Greater than 90% chance of finding a high temperature (125°C) resource at depths less than 3 km.

It should be noted that although the majority of the southwest rift zone is situated within the Hawaii Volcanoes National Park and is therefore off-limits to geothermal development, the potential for geothermal resource along the entire Kilauea Southwest Rift Zone was assessed by the Committee.

G. KOHALA VOLCANO

Groundwater Temperature. No positive indications from groundwater data.

Geologic Age. The most recent activity occurred about 60,000 years ago and was most active at least 300,000 years ago (Macdonald and Abbott, 1970).

Geochemistry. No significant data.

Resistivity. Data from Direct Current (DC) soundings did not show any positive indications of geothermal resource (Kauahikaua, et al, 1979).

Infrared Survey. No available data.

Seismic. No concentration of seismic activity.

Magnetics. Aeromagnetic data did not identify any strong anomalies (Godson, et al, 1981).

Gravity. No significant data.

Exploratory Drilling. No deep exploratory well data.

Self Potential. No available data.

Conclusion:

Due to the limited data and the absence of any signficant anomalies and based on the younger age of Kohala relative to Olowalu-Ukumehame on Maui, the following probabilities were concluded:

- Less than 10% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.

- Less than 5% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It should be noted that due to the limited amount of data, additional studies are warranted in the future in order to update our current assessment.

H. MAUNA KEA

Groundwater Temperature. One groundwater temperature anomaly recorded in a deep well on the Northwest Rift Zone at Waikii, Well No. 5239-01 (104°F at 4240-foot depth) . No temperature anomalies recorded for shallow wells along the coast.

Geologic Age. Mauna Kea volcano is substantially younger than Kohala, having been formed over 200,000 years ago. Mauna Kea is presently in its post-caldera stage of activity with the most recent eruption occurring about 3600 years ago (Macdonald and Abbott, 1970; Porter, 1979).

Geochemistry. No significant data.

Resistivity. No available data.

Infrared Survey. No available data.

Seismic. Definite seismic swarm and deep seismic activity recorded along the East Rift Zone.

Magnetics. Available data shows no positive indication of geothermal resource and pertains to identification of structural features within the summit (Malahoff and Wollard, 1965; Godson, et al, 1981).

Gravity. No significant data.

Exploratory Drilling. Waikii Well No. 5239-01, drilled at elevation 4260 ft. to a depth of 4,350 feet. A bottom-hole (near sea level) temperature of 104°F recorded.

Self Potential. No available data.

Conclusion:

On the basis of geologic age and one groundwater temperature anomaly recorded at the Waikii well, the following probabilities were concluded:

Mauna Kea Northwest Rift Zone -

- Less than 50% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- Less than 20% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Mauna Kea East Rift Zone -

- Less than 30% chance of finding a low temperature (50-125°C) resource at depths less than 3 km.
- Less than 10% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

It was noted again that due to the limited amount of available data, additional studies are warranted in the future in order to update our current assessment.

Afternoon Session

The meeting was reconvened by Manabu Tagomori and dates, locations, and topics of future meetings were discussed and tentatively scheduled as follows:

Date	Place	Topic of Discussion
April 18 (Wed.)	Hawaii	Air inspection of Kilauea Rift Zone. Tour of Puna Geothermal Venture and Barnwell Drilling Sites, and inspection of the HGP-A Facility.
April 19 (Thurs.)	Hawaii	Assessment of Geothermal Resources on Kilauea East Rift Zone. Mapping by the Committee of all potential geothermal resource areas.
May 11 (Fri.)	Honolulu	Assessment Review Session.

It was suggested that an additional meeting be scheduled sometime in May to discuss the impacts of geologic hazards. The committee was also invited to participate in the impact analysis of geothermal development on the environment.

The meeting was adjourned at 3:30 pm.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
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AGENDA

Geothermal Resource Subzone Technical Committee

Field Trip to Kilauea East Rift Zone
April 18, 1984

8:00 am	Leave Honolulu
9:00 am	Air inspection No. 1 - Kilauea Rift Zone
10:00 am	Air inspection No. 2 - Kilauea Rift Zone
11:00 am	Ground inspection of Upper Kilauea Rift Zone
12:00 N	Lunch
1:30 pm	Tour of Puna Joint Venture geothermal wells
2:30 pm	Tour of Barnwell geothermal wells
3:30 pm	Tour of HGP-A well
4:30 pm	Adjourn

MINUTES

Geothermal Resources Technical Committee
Meeting No. 4

Date: April 18, 1984

Time: 8:00 am - 12:00 Noon; 1:30 pm - 4:30 pm

Place: USGS Hawaiian Volcano Observatory (morning)
Barnwell and Thermal Power Geothermal Well Sites (afternoon)

Participants: Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
Dallas Jackson, HVO
Richard Moore, HVO
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Morning

Manabu Tagomori called the meeting to order and addressed the issue regarding the recent eruptive activity. The committee reviewed the middle east rift eruption of Kilauea which began on January 3, 1983 and has continued intermittently throughout 1984. To date, Kilauea erupted at Pu'u O for phase 17 which began at 5:15 am on March 30, 1984 and ended at 3:24 am on March 31, 1984. Seismic data indicated that the magma conduit along the east rift zone has not significantly changed.

The committee discussed the area covered by the recent lava flows and the extent of the phase 17 flow front which reached the 400-foot elevation about 1 km east of Royal Gardens subdivision. The technical group noted the probability of a resumption of eruptive activity and discussed the possible directions that the new lava flows might take with respect to Royal Gardens subdivision. It should be noted that the direction and rate of flow is dependent on many factors such as type of vegetation and the existence of earlier flows.

The technical committee was also briefed on the recent Mauna Loa eruption which began on March 25, 1984. The major portion of lava erupted from a 150-meter long fissure on Mauna Loa's northeast rift zone near the 9,500-foot elevation, about 2 km northeast of Pu'u Ulaula.

A field trip to the visitor center near Wahaula Heiau provided the committee a view of Royal Gardens subdivision and the extent of the lava flows that damaged 15 dwellings and covered about 330 lots and their access roads.

The scheduled air inspection of the Kilauea eruption site was cancelled due to inclement weather.

Afternoon

The meeting was reconvened by Manabu Tagomori at the site of geothermal well, Lanipuna No. 6, followed by a tour of the drilling operation by Bill Craddick from Barnwell Geothermal Corp.

The committee moved to the site of Kapoho State Wells No. 1 and 2 and a briefing was conducted by Joe Iovenitti from Thermal Power Co. Questions were answered regarding the Kapoho State No. 1 blowout and Mr. Iovenitti pointed out that various security devices have been installed at the well site. The site of the future Kapoho State No. 1A, although not finalized, is to be located within the original drill site of Kapoho State No. 1.

Mr. Tagomori thanked the committee again for their continued assistance and the meeting was adjourned at 4:30 pm.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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AGENDA

Geothermal Resource Subzone Technical Committee
Meeting No. 5

April 19, 1984
University of Hawaii, Hilo
Hilo, Hawaii

8:00 am	Call to order: Manabu Tagomori
	Presentation by Mid-Pacific Geothermal, Inc.
8:45 am	Presentation by Barnwell, Inc.
9:30 am	Presentation by Puna Joint Venture
10:15 am	Approval of Minutes
	Announcements
	Technical Session Leader: Donald Thomas
o	Review conclusions on Hawaii, generally
12:00 N	Lunch
1:00 pm	Air Inspection No. 1 - Kilauea Rift Zone
2:00 pm	Air Inspection No. 2 - Kilauea Rift Zone
4:00 pm	Adjourn

MINUTES
(Amended)

Geothermal Resources Technical Committee
Meeting No. 5

Date: April 19, 1984

Time: 8:00 am - 12:00 Noon, 1:00 pm - 5:00 pm

Place: University of Hawaii, Hilo Campus (morning)
Pu'u O Vent, Kilauea East Rift Zone (afternoon)

Participants: Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
John Sinton, HIG
Bill Chen, UH-Hilo
Dallas Jackson, HVO
Richard Moore, HVO
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

A list of developers and their representatives present at the meeting is attached.

Morning

Meeting was called to order by Manabu Tagomori, who briefed the committee on the morning agenda regarding presentation of technical data by the three geothermal developers (True/Mid Pacific, Barnwell, and Puna Geothermal Venture).

True/Mid Pacific

The meeting was turned over to Rod Moss (Mid-Pacific Geothermal) and Allan Kawada (True Geothermal) who introduced Gerald Niimi from Thermasource, Inc. and Sam Keala, Jr., representing Campbell Estate.

Rod Moss emphasized the goal of True/Mid Pacific to drill north of the rift zone rather than to the south. Mr. Niimi stated that Thermasource, Inc. conducted a regional and site specific study of Kahaualea, and data indicated a potential geothermal resource with adequate groundwater recharge. Data was submitted to the committee by Mr. Niimi to support his conclusion that the north side of the rift would have the greatest potential (Holcomb, 1980; Koyanagi, 1978, Godson, et al, 1981; Kinoshita, 1965). Mr. Niimi recommended that his client initially drill close to the rift to observe the reservoir then develop northward away from possible future lava flows. It was noted that the nearest Kilauea lava flow is about 500 feet away from the proposed KA-1 drill site.

True/Mid Pacific has been granted conditional approval of up to 8 exploratory wells within a restricted area containing approximately 800 acres, with long range plans to develop a total of about 7,800 acres within Kahaualea.

Puna Geothermal Venture/Thermal Power

Mr. Iovenitti presented technical data by Howard Ross in addition to a mylar overlay outlining aeromagnetic data (Godson, et al, 1981), mercury and radon data (Cox, 1980), and water well locations with chemical and temperature information.

It was stated by Mr. Iovenitti that a recent aeromagnetic survey (not yet made public) noted areas of low magnetism related to high temperature or hydrothermal alteration and indicated the possibility of a parallel dike complex running along the coast. Based on the data presented, Mr. Iovenitti concluded that the middle rift from Kapoho State No. 1 and 2 north to Lava Tree State Park showed considerable potential.

It was recommended that future exploration be moved away from the dike complex which may restrict permeability although the area may be hot. Mr. Iovenitti further stated that seawater intrusion is not a reservoir problem with regard to precipitation of calcium and anhydrite possibly sealing off the reservoir.

Mr. Iovenitti discussed the difference in geothermal systems between HGP-A (50% water, 50% steam) and Kapoho State Wells (100% steam). It was suggested that the difference could be attributed to the depth of casing; Kapoho State No. 1 and 2 being cased to approximately 4500 feet depth, versus HGP-A which is cased to about 2900 feet depth.

The committee was informed that both wells, Kapoho State No. 1 and 2 had debris (drill rods and wireline) within the casing.

Barnwell

Bill Craddick representing Barnwell Geothermal Corp. and Murray Gardner from Geothermex, Inc., consultant to Barnwell/WRII, presented background information and data to the committee. Mr. Gardner stated the possibility of directional drilling at Ashida No. 1 in the north-northwest direction to locate a zone of permeability. Ashida No. 1 drilled to 8000-foot depth is hot (approximately 543°F) but lacks a permeable reservoir. Lanipuna No. 1 reported to have a well temperature of approximately 685°F also has the problem of low permeability.

It was noted that a minimum temperature of 450°F for deep wells and 350°-400°F for shallow wells are needed to be economically feasible for electrical production.

Mr. Gardner stated that the Halekamahina area, owned by Tokyu Land Development Co. would possibly be the site of future exploration. He also mentioned that a report on rock thin sections had been submitted to DLNR through Barnwell Geothermal Corp.

Mr. Tagomori thanked all of the developers and their representatives for their continued support and invited them to submit any additional information pertaining to the environmental impact of geothermal development.

Afternoon

The meeting was reconvened by Manabu Tagomori at the Hawaiian Volcano Observatory. Arrangements were made by HVO staff geologist Reggie Okamura for use of a helicopter to airlift the technical committee to the site of the recent "1123" vent. From this location and while in flight the committee was able to inspect the Kahaualea area covered by lava flows from the previous 17 phases of the Kilauea eruption.

Phase 18 of volcanic activity had begun at Pu'u O vent on the evening of April 18, 1984. The air inspection provided the committee an excellent overview of the current eruption and the extent of the 3 lava flows that were traveling toward the north, northeast, and south. While situated at the "1123" vent, the committee discussed the probability of future lava flows endangering the Royal Gardens subdivision.

Upon our return to the takeoff and landing area at the Kilauea Military Camp in the National Park, the meeting was adjourned at 5:00 pm.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

Developers and Consultants at the
Geothermal Resources Technical Committee
Meeting No. 5

April 19, 1984

NAME	ORGANIZATION
Samuel L. Keala, Jr.	Campbell Estate
Allan G. Kawada	True Geothermal Energy Co.
Gerald Niimi	Thermasource, Inc.
Rod Moss	Mid-Pacific Geothermal, Inc.
Joe Iovenitti	Thermal Power Co.
Bill Craddick	Barnwell Geothermal Corp./WRII
Murray C. Gardner	Geothermex, Inc.

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AGENDA

Geothermal Resource Subzone Technical Committee
Meeting No. 6

April 23, 1984
Hawaii Institute of Geophysics (Conference Room)
University of Hawaii
Honolulu, Hawaii

9:00 am	Call to order: Manabu Tagomori
	• Approval of Minutes
	• Assessment of geothermal resources of Kilauea East Rift Zone
12:00 N	Lunch
1:00 pm	Mapping of geothermal resource areas
4:00 pm	Adjournment

MINUTES
(Amended)

Geothermal Resources Technical Committee
Meeting No. 6

Date: April 23, 1984

Time: 9:00 am - 12:00 Noon; 1:15 pm - 4:00 pm

Place: HIG Conference Room, University of Hawaii

Participants:
Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
Dan Lum, DOWALD
John Sinton, HIG
Dallas Jackson, HVO
Richard Moore, HVO
James Kauahikaua, USGS
Bill Chen, UH-Hilo
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Morning

Manabu Tagomori called the meeting to order and thanked the committee members for their continued assistance.

Copies of the amended minutes for the March 30, 1984 meeting along with minutes of the April 9, 1984 meeting were distributed to the committee for their review and comments.

The meeting was turned over to Don Thomas who continued with the assessment of geothermal resources for the Kilauea East Rift Zone. Based upon the evaluation of available information, the following probability for geothermal resource was concluded by the Technical Committee.

ASSESSMENT OF THE ISLAND OF HAWAII

KILAUEA EAST RIFT

Groundwater Temperature. Numerous temperature anomalies recorded in wells along the lower East Rift Zone. Well No. 2686-02 (102°C), Well No. 2982-01 (93°C), Well No. 2685-01 (285°C) (Epp and Halunen, 1979; Macdonald, 1975).

Geologic Age. Frequent activity recorded along the rift zone with many recent eruptions and repeated dike intrusions. Data indicates possible secondary magma chambers capable of substantial magma storage (Moore, 1982, 1983; Wright and Fiske, 1971; Holcomb, 1980, 1981; Swanson et al, 1976).

Geochemistry. Water samples identified numerous geochemical anomalies along the rift zone. Data indicated thermal alteration of the chloride to magnesium ion concentration ratios (McMurty et al, 1977; Kroopnick et al, 1978; Cox and Thomas, 1979; Druecker and Fan, 1976).

Resistivity. Thermally related low resistivity anomalies recorded in many parts of the rift zone (Keller et al, 1977; Kauahikaua and Mattice, 1981).

Infrared Surveys. Some infrared anomalies identified on the rift zone and along the coast (Fischer et al, 1966; Abbott, 1974).

Seismic. Data indicates that the entire rift is extremely active. Numerous seismic events concentrated on the rift have strong indications of magma intrusion (Koyanagi et al, 1981, Furumoto, 1978; Suyenaga et al, 1978; Mattice and Furumoto, 1978; HVO monthly reports; Thermasource, Inc. report).

Magnetic. Major aeromagnetic anomalies were observed, associated with the Kilauea East Rift Zone (Godson et al, 1981; Malahoff and Woollard, 1965; Furumoto, 1978).

Gravity. Strong expression of the rift zone, not particularly related to geothermal potential (Kinoshita, 1965).

Exploratory Drilling. Seven deep wells drilled, all having high temperatures (greater than 125°C), but not all have adequate permeability for development.

Self Potential. Numerous self-potential anomalies observed, possibly associated with fumaroles or intrusives having high temperature or the movement of thermal groundwater (Zablocki, 1976, 1977; Jackson, 1983).

Conclusion:

On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, the following probability was concluded:

- Greater than 90% chance of finding a low temperature (50-125°C) and high temperature (greater than 125°C) resource at depths less than 3 km.

Afternoon

The meeting was reconvened by Don Thomas and the technical group began its mapping of High Temperature Potential Geothermal Areas based on the conclusions of the committee. After some discussion by the members, it was agreed that only those areas having an assessed probability of at least 25% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km would be mapped.

It should be noted that there was some disagreement between technical members as to the importance placed on certain data and to the area encircled within the probability lines. After some debate a compromise was reached where equal weight would be given to all positive data and the probability areas mapped would be below the 7000-foot elevation due to the limits of current drilling technology.

Attached are a series of maps showing the following High Temperature Potential Geothermal Resource Areas and their percent probabilities:

	% Probability for High Temperature
Maui	
Haleakala SW Rift Zone	25% or less
Haleakala East Rift Zone	25% or less
Hawaii	
Kilauea East Rift Zone	Greater than 90%
Kilauea SW Rift Zone	Greater than 90%
Mauna Loa NE Rift Zone	35% or less
Mauna Loa SW Rift Zone	35% or less
Hualalai	35% or less

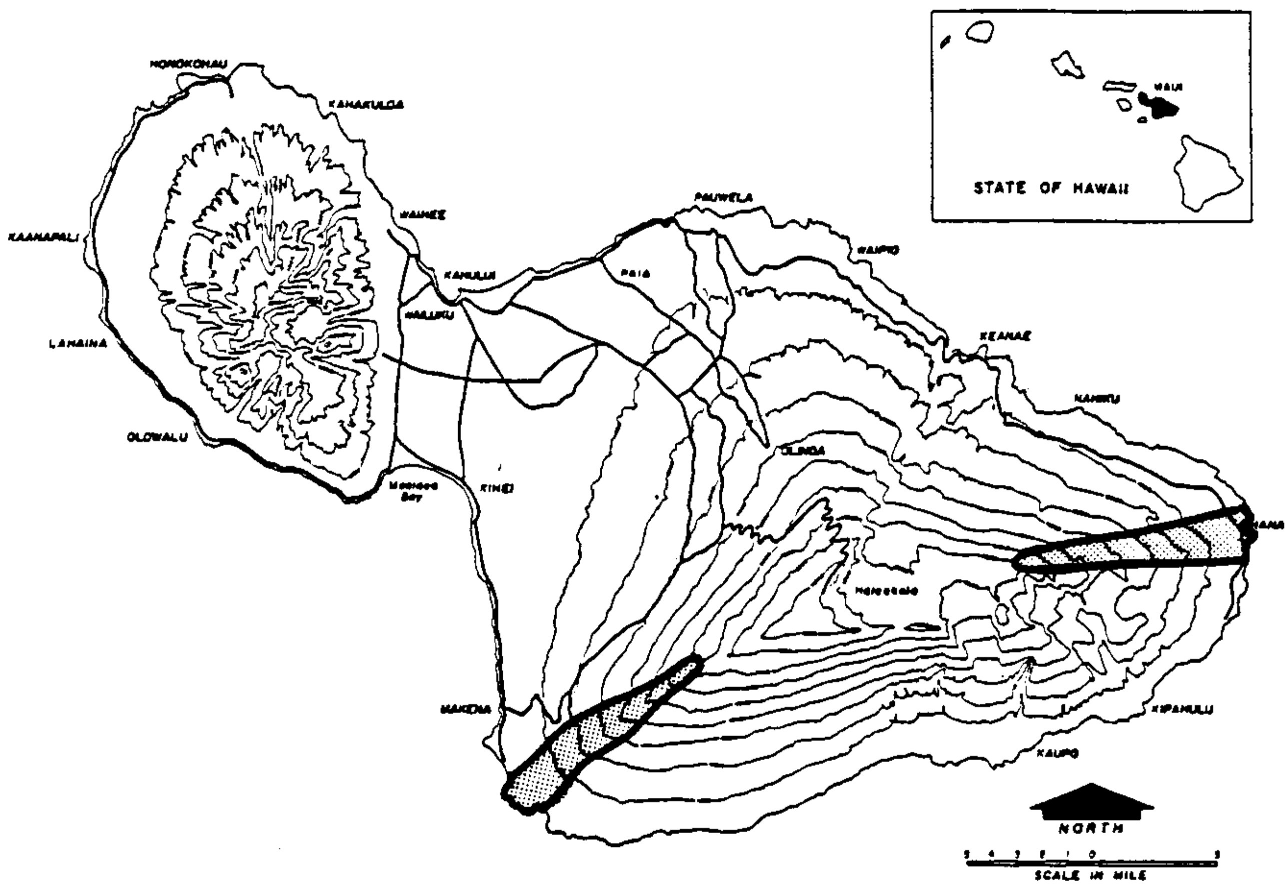
The date for the Assessment Review Session was set for May 11, 1984, to be held at the HIG conference room in Honolulu. It was suggested that an additional meeting be scheduled later in May to discuss the impact of geologic and environmental hazards. The committee members were also invited to participate in the public information meetings set for May 8 and 29 on Hawaii and May 9 and 30 on Maui.

The meeting was adjourned at 4:00 pm.

DEAN NAKANO

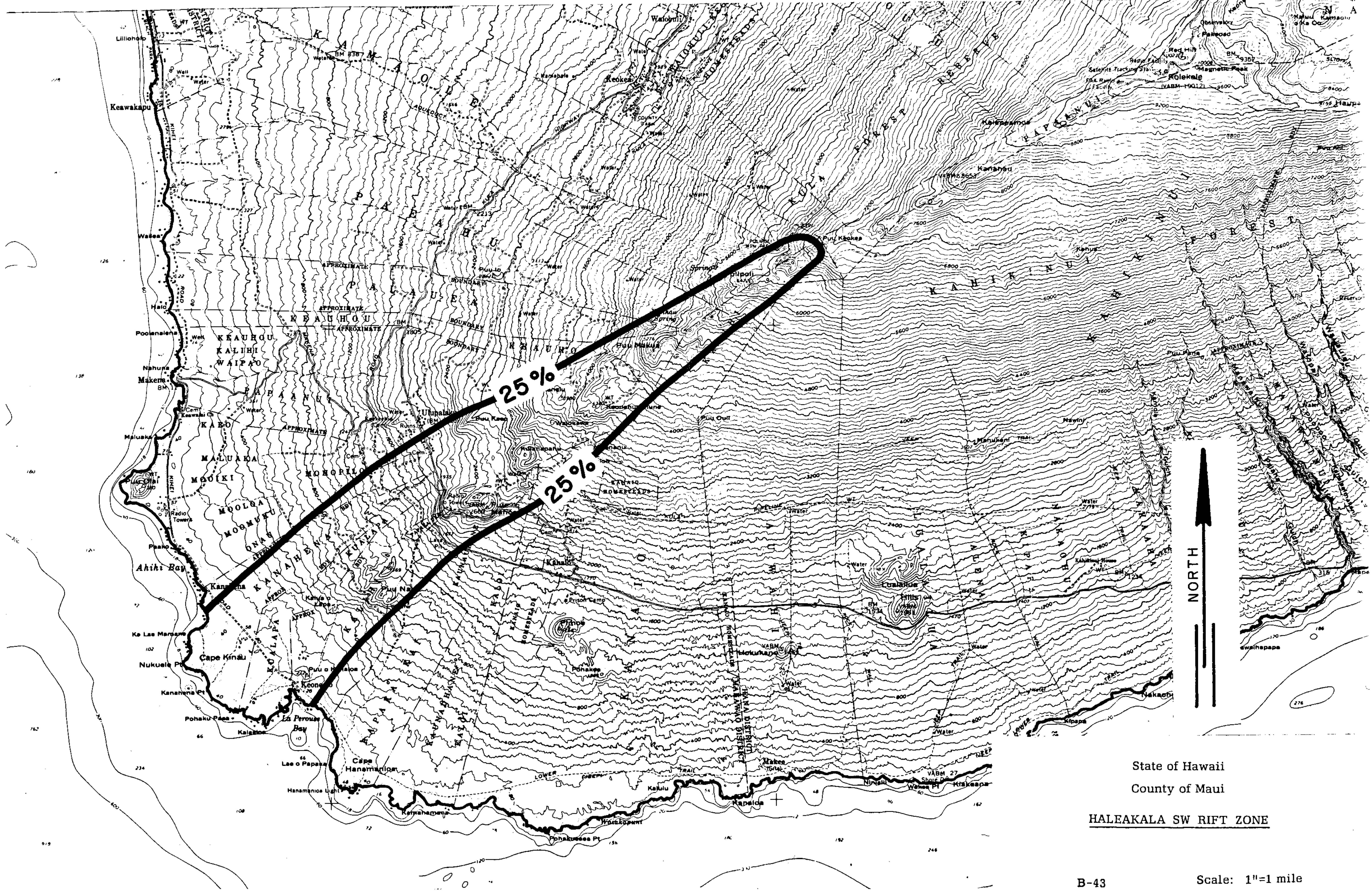
APPROVED:

MANABU TAGOMORI



HIGH TEMPERATURE POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Maui



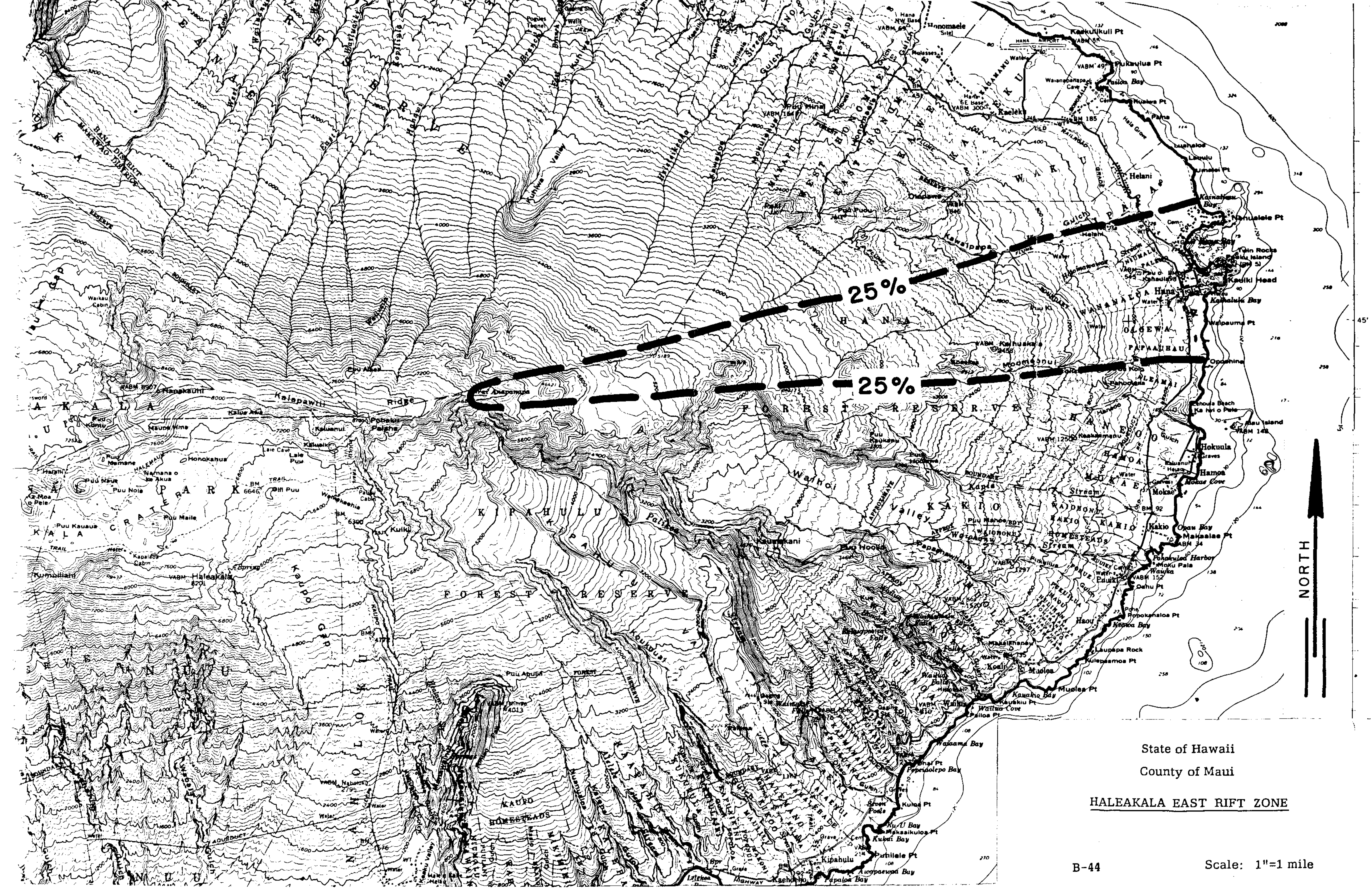
State of Hawaii

County of Maui

HALEAKALA SW RIFT ZONE

B-43

Scale: 1"=1 mile

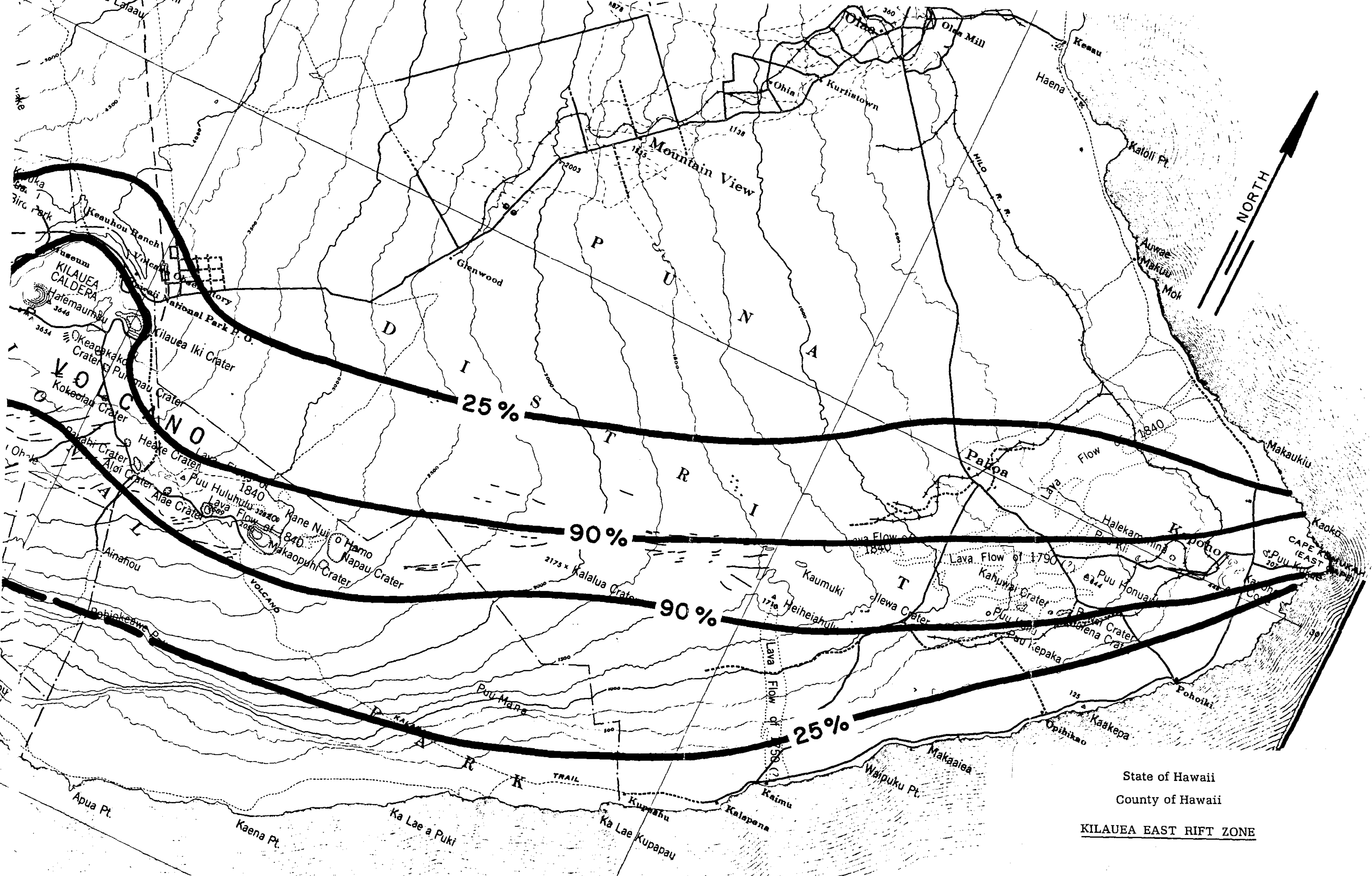


State of Hawaii

County of Maui

HALEAKALA EAST RIFT ZONE

B-44



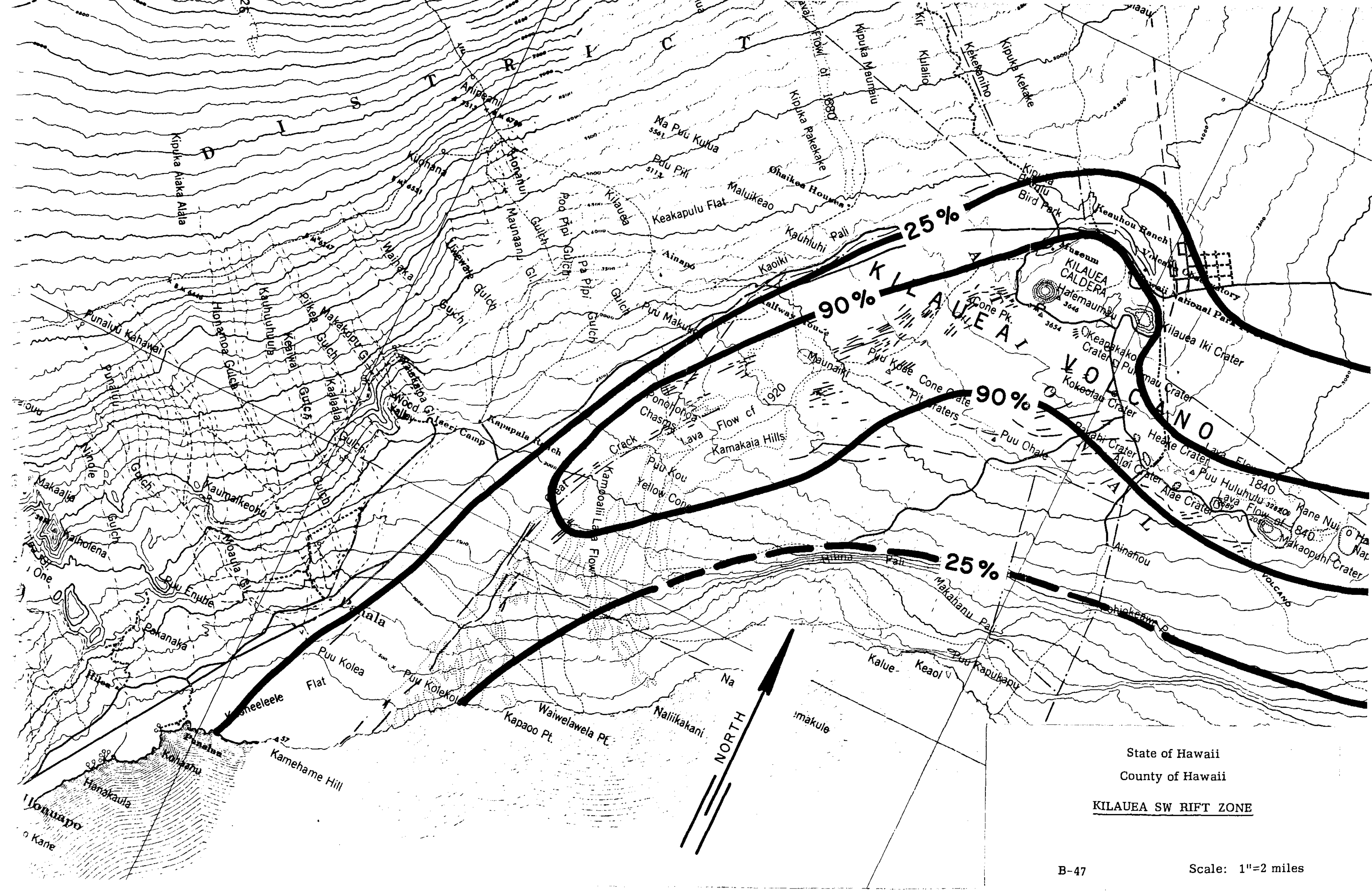
State of Hawaii

County of Hawaii

KILAUEA EAST RIFT ZONE

B-46

Scale: 1"=2 miles



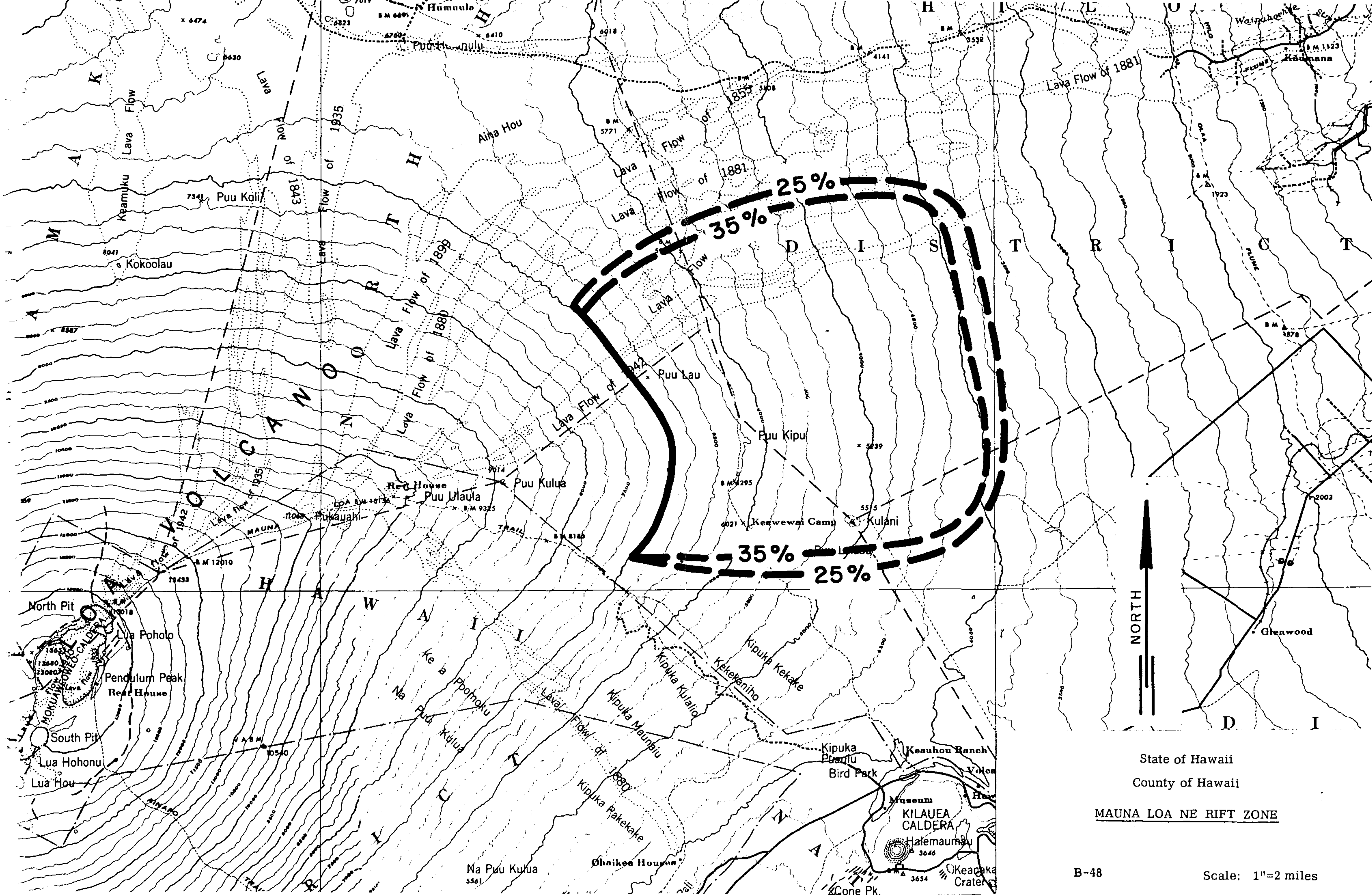
State of Hawaii

County of Hawaii

KILAUEA SW RIFT ZONE

B-47

Scale: 1"=2 miles



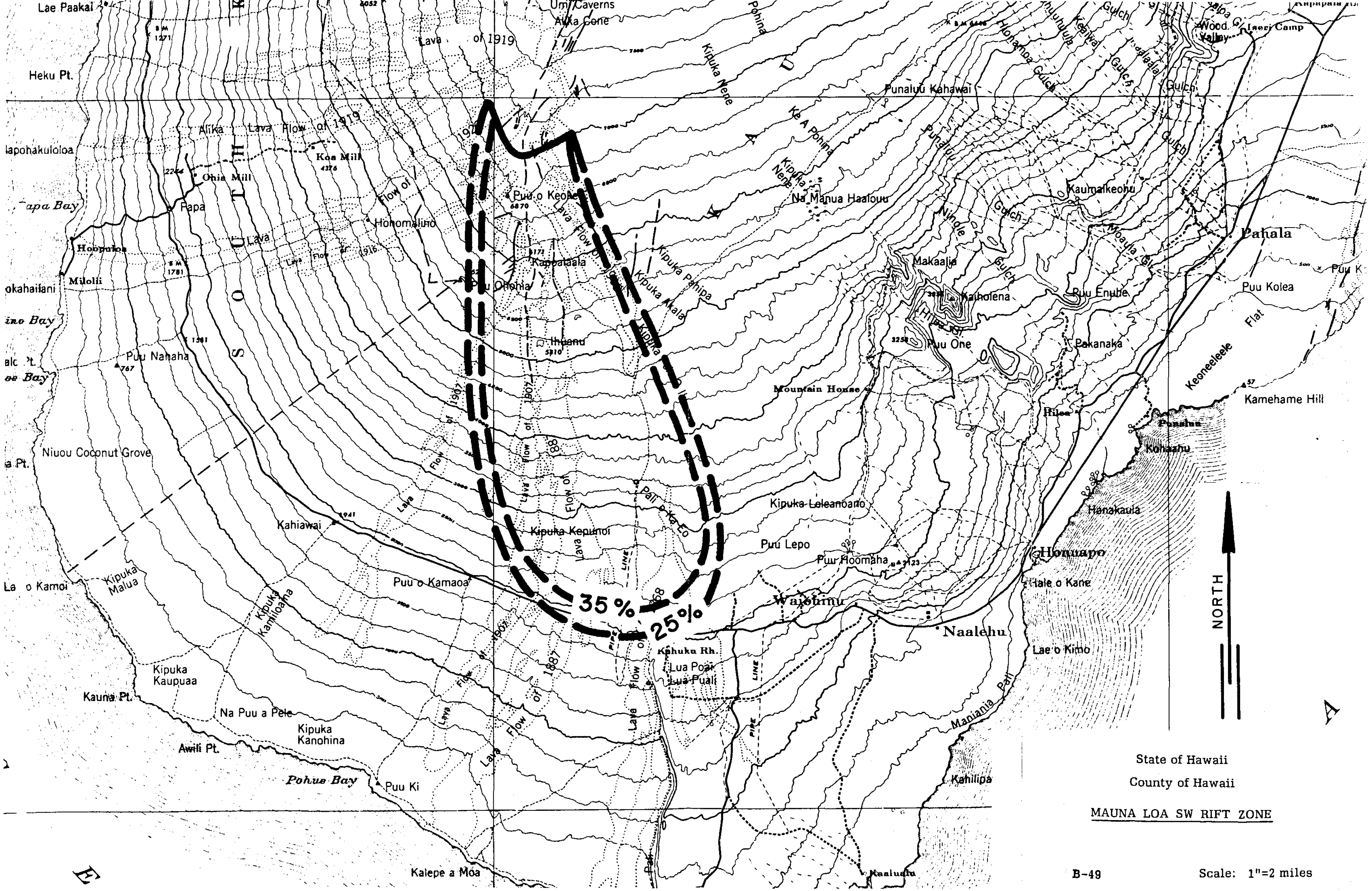
State of Hawaii

County of Hawaii

MAUNA LOA NE RIFT ZONE

B-48

Scale: 1"=2 miles



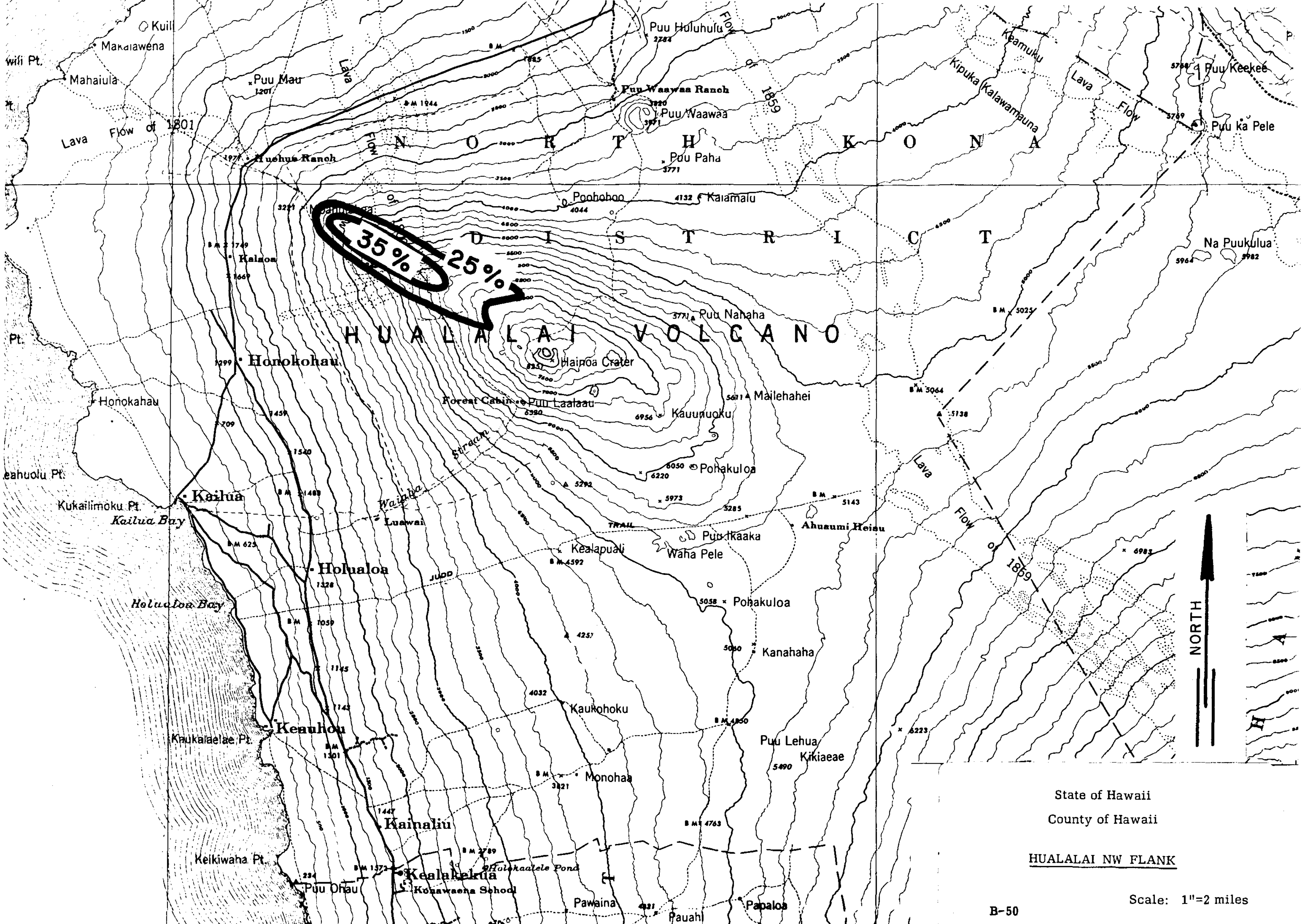
State of Hawaii

County of Hawaii

MAUNA LOA SW RIFT ZONE

B-49

Scale: 1"=2 miles



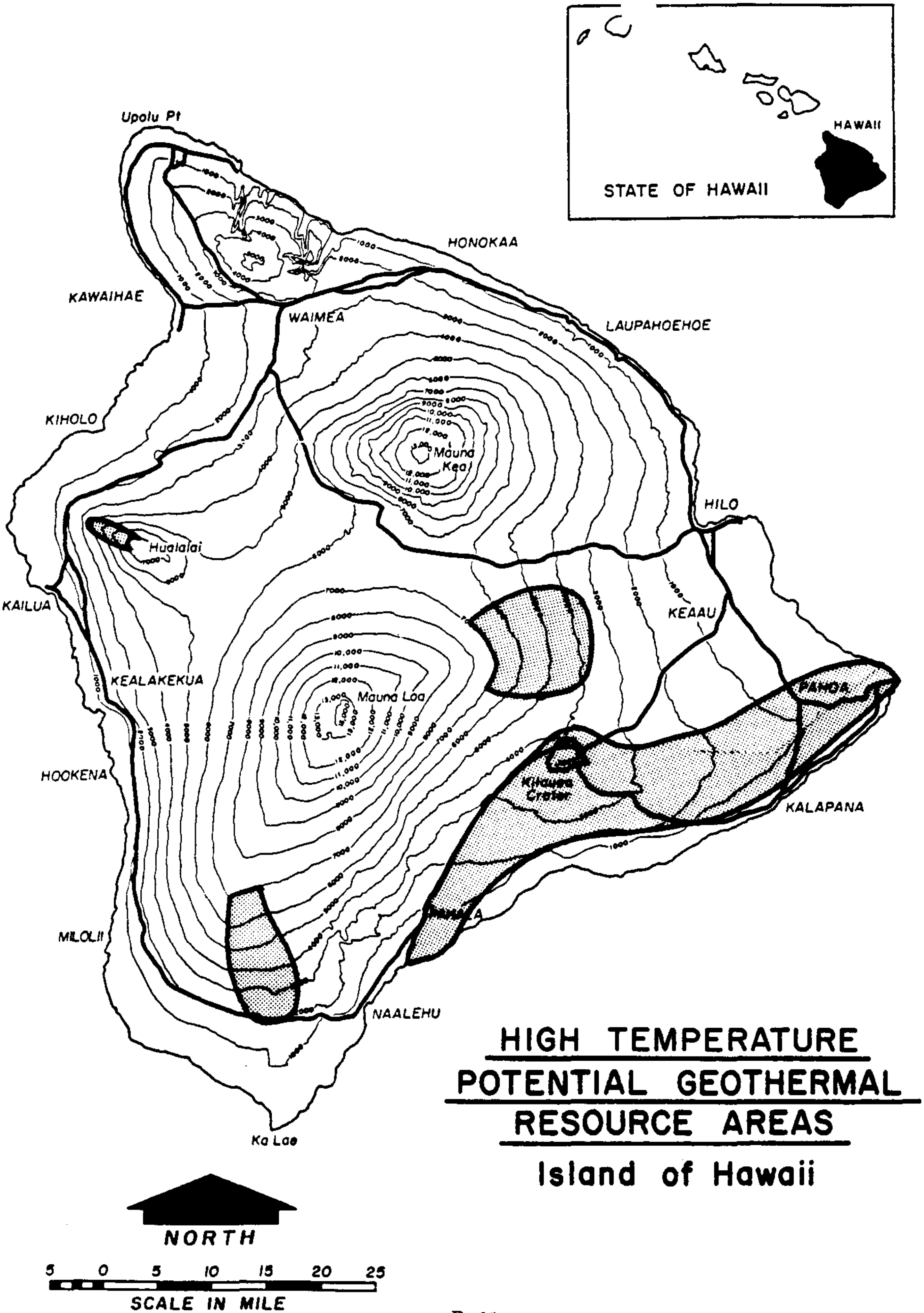
State of Hawaii

County of Hawaii

HUALALAI NW FLANK

Scale: 1"=2 miles

B-50



HIGH TEMPERATURE POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Hawaii

AGENDA

Geothermal Resources Technical Committee
Meeting No. 7

May 11, 1984
Hawaii Institute of Geophysics (Conference Room)
University of Hawaii
Honolulu, Hawaii

9:00 am Call to Order (Manabu Tagomori)

- Approval of Minutes
- Review of Potential Geothermal Resource Areas
  - High Temperature Areas (maps)
  - Low Temperature Areas (listing)
- Review of Public Information Meetings

12:00 Noon - Lunch

1:00 pm Continue Morning Session

- Discussion on Geologic Hazards
- Discussion of Other Impacts

3:00 pm Adjournment

MINUTES

Geothermal Resources Technical Committee
Meeting No. 7

Date: May 11, 1984

Time: 9:00 am - 10:00 Noon; 1:00 pm - 4:00 pm

Place: Division of Water & Land Development Conference Room

Participants: Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
Richard Moore, USGS
James Kauahikaua, USGS
John Sinton, HIG
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Agenda is attached.

Morning

Manabu Tagomori called the meeting to order at 9:10 am. The Committee was asked to comment on the minutes of the previous meetings and review the lines drawn for the potential geothermal resource area maps.

Mr. Tagomori discussed the recent public participation and information meetings held at Hilo, Hawaii on May 8, 1984 and at Kahului, Maui on May 9, 1984. Dr. Thomas stated that public comments were received regarding direct heat use (e.g. food processing), and for the identification of areas capable of this type of heat application.

The next public informational meetings are scheduled for May 29 and 30, 1984 on Hawaii and Maui, respectively. Mr. Tagomori stated that additional informal meetings are tentatively planned for both islands sometime in mid-June. These meetings are to be scheduled in conjunction with the local community association meetings held in each respective area. It was further noted that public hearings on the Administrative Rules on the Designation and Regulation of Geothermal Resource Subzones are to be held on all islands on May 22, 1984.

Copies of the "Reconnaissance Geological Investigations of Geothermal Energy Potential of Kohala, Lanai, and West Molokai Volcanoes, Hawaii" report by L. T. Grose, submitted to the Department of Land and Natural Resources by Mr. Ed Craddick were distributed to members of the Committee. It was recommended that Committee members review this additional data prior to continuation of the Technical Committee meeting at 1:00 pm today.

Afternoon

The meeting was reconvened by Manabu Tagomori and the technical group began its review of the report by L. T. Grose, dated January 24, 1978. The Committee concluded that the report did not contain any significant new data regarding Kohala, Lanai and Molokai and that the Committee's earlier conclusions would not have to be changed.

Upon evaluation of the complete list of percentages, the Committee selected seven High Temperature and five Low Temperature Potential Geothermal Resource Areas. The selection of a low temperature resource area was based on the area having an assessed probability of at least 15% chance of finding low temperature (less than 125°C) resource at depths less than 3 km. These low temperature resource areas were not mapped but are included in a list of the Committee's selections for potential geothermal resource areas that is attached.

The technical members began their review of the High Temperature Potential Geothermal Resource area maps based on the Committee's earlier conclusions. After some discussion by the Committee, it was noted that only those areas having an assessed probability of at least 25% chance of finding high temperature (greater than 125°C) resource at depths less than 3 km should be mapped. These revisions to the earlier maps would be made on the basis that any probability lower than that value would be so small that there would be little justification to accurately draw a probability boundary line. These revised maps are to be attached to the amended minutes for meeting No. 6.

Dr. Thomas was asked to define the use of hashed lines versus solid lines in the mapping of certain potential geothermal resource areas. It was stated that due to the limited data available, there was less justification to clearly draw a solid boundary line locating the resource area.

The Technical Committee reviewed a complete tabulation of the percent probabilities for the State of Hawaii. This county-by-county assessment based on the potential for high and low temperature resource is attached.

Mr. Tagomori asked the Technical Committee to discuss the impacts of geologic hazards, specifically earthquakes and lava flows, on the selected potential geothermal resource areas.

It was noted that earthquakes having a magnitude 6.0 or greater should be taken into consideration. Since 1951, four significant earthquakes have occurred, ranging in magnitude from 6.2 to 7.2 on the Richter scale. The Committee agreed that while earthquakes are a definite hazard, it would be extremely difficult to accurately predict their occurrence or potential damage.

Historic lava flows were discussed with regard to their duration and areal extent. It was noted that while elevated ground should be considered for power plant locations, evidence indicates that selection of high ground is not entirely safe from inundation by lava flows. The pattern of eruptions along the Kilauea East Rift Zone suggests a migration of eruptive vents, but the actual location of future vents cannot be accurately predicted.

Dr. Thomas suggested that while inundation by lava flows is a definite concern, more consideration should be given to the potential loss of electrical power from damage to the power plant. It was noted that the assessment of geologic hazards could be based on a power loss criteria, where a predetermined concentration of power production (e.g. 50 MW within a 1000-acre parcel), should not exceed the replaceable amount of electricity that the utility company could restore through alternate means during a power plant shut-down.

The Committee agreed that since all surface lava flows have occurred within the last 1000 years and strictly on the basis of geologic time, the Kilauea rift zone should be considered active. Although past history of events could give some idea of what could occur, it would be difficult to accurately predict the future occurrence of geologic hazards with any degree of scientific certainty.

Mr. Tagomori thanked the Committee for their continued assistance in this assessment phase, and suggested that a future meeting be held sometime in June after the May 29 and 30 public participation and information meetings. A tentative date was set for June 8, 1984 in Honolulu.

The meeting was adjourned at 4:00 pm.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

POTENTIAL GEOTHERMAL RESOURCE AREAS

HIGH TEMPERATURE RESOURCE AREAS (greater than 125°C at depths less than 3 km)

	Percent Probability
Maui:	
Haleakala S.W. Rift Zone	25% or less
Haleakala East Rift Zone	25% or less
Hawaii:	
Hualalai	35% or less
Mauna Loa S.W. Rift Zone	35% or less
Mauna Loa N.E. Rift Zone	35% or less
Kilauea East Rift Zone	Greater than 90%
Kilauea S.W. Rift Zone	Greater than 90%

LOW TEMPERATURE RESOURCE AREAS (less than 125°C at depths less than 3 km)

Statewide	Percent Probability
Waianae, Oahu	15% or less
Olowalu-Ukumehame, Maui	75% or less
Kawaihae, Hawaii	45% or less
Mauna Kea N.W. Rift Zone, Hawaii	Less than 50%
Mauna Kea East Rift Zone, Hawaii	Less than 30%

PERCENT PROBABILITIES

(County-by-County)

Island/Area	High Temperature (greater than 125°C at depths less than 3 km)	Low Temperature (less than 125°C at depths less than 3 km)
KAUAI	Less than 5%	Less than 5%
OAHU		
Waianae	Less than 5%	15% or less
Koolau	Less than 5%	Less than 10%
MOLOKAI	Less than 5%	Less than 5%
LANAI	Less than 5%	Less than 5%
MAUI		
Olowalu-Ukumehame	Less than 15%	75% or less
Lahaina-Kaanapali	Less than 5%	Less than 5%
Honolua	Less than 5%	Less than 5%
Haleakala S.W. Rift	25% or less	35% or less
Haleakala N.W. Rift	Less than 5%	Less than 10%
Haleakala East Rift	25% or less	35% or less
HAWAII		
Kawaihae	Less than 10%	45% or less
Hualalai	35% or less	70% or less
Mauna Loa S.W. Rift	35% or less	60% or less
Mauna Loa N.E. Rift	35% or less	60% or less
Kohala	Less than 5%	Less than 10%
Mauna Kea N.W. Rift	Less than 20%	Less than 50%
Mauna Kea East Rift	Less than 10%	Less than 30%
Kilauea S.W. Rift	Greater than 90%	Greater than 90%
Kilauea East Rift	Greater than 90%	Greater than 90%

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
P. O. BOX 373
HONOLULU, HAWAII 96809

AGENDA

Geothermal Resources Technical Committee
Meeting No. 8

June 8, 1984
Hawaii Institute of Geophysics (Conference Room)
University of Hawaii
Honolulu, Hawaii

9:00 am Call to Order

- Approval of Minutes
- Review of Draft Committee Report

10:00 pm Adjournment

MINUTES

Geothermal Resources Technical Committee
Meeting No. 8

Date: June 8, 1984
Time: 9:00 am - 12:00 Noon
Place: HIG Conference Room, University of Hawaii

Participants: Manabu Tagomori, Chairman, DOWALD
Donald Thomas, HIG
Daniel Lum, DOWALD
John Sinton, HIG
Richard Moore, HVO
Bill Chen, UH-Hilo
Joe Kubacki, DOWALD
Dean Nakano, DOWALD

Manabu Tagomori called the meeting to order and briefly reviewed the Departmental activities underway for the Committee's general information.

* S.B. 2184-84 was signed into law on May 23, 1984 and is now Act 151. The new law contains a "grandfather clause" which automatically subzones an existing BLNR geothermal mining lease area having a county special use permit.

* Public hearings on the Administrative Rules held in each county on May 22, 1984 and public information and participation meetings held on Hawaii and Maui on May 29 and 30 respectively. Additional meetings have been scheduled for July 10 and 11 with the Pahoa and Volcano Community Associations.

* Briefing of the Board of Land and Natural Resources will be held on June 21 and preliminary subzone designations and site specific public hearings are tentatively scheduled for sometime in August.

The first draft of the Statewide Geothermal Resource Assessment report mailed prior to the meeting was briefly discussed. Dean Nakano highlighted the draft report for discussion purposes. Don Thomas noted that for consistency, we should standardize the probability percentages by using "% or less" rather than just a sole "%" figure. The committee agreed to revise the table on percent probabilities as a result of these changes.

It was also recommended that wherever possible geothermal resource area maps should depict two boundary lines of percent probablity. This additional information would be valuable during the impact analysis and preliminary subzone designation by the Board of Land and Natural Resources.

A final draft will be mailed to each member and at that time signatures will be sought from the committee members.

Mr. Tagomori thanked the committee for their valuable time and asked for continued assistance during the entire assessment study. He advised the members that any future meetings would be on an on-call basis.

The meeting was adjourned at 12:00 noon.

DEAN NAKANO

APPROVED:

MANABU TAGOMORI

APPENDIX C

BIOGRAPHIES OF TECHNICAL COMMITTEE MEMBERS

MANABU TAGOMORI
3035 Hiehie Street
Honolulu, Hawaii 96822

- Born and raised in Kahului, Maui.
- Educated at Kahului School and Baldwin High School on Maui and graduated from the University of Hawaii at Manoa in 1957 with a Bachelor of Science degree in Civil Engineering.
- Registered Professional Engineer in Hawaii.
- 1957-1959, employed as design engineer with the Hawaii Water Authority.
- 1959-1972, served as design and project planning engineer with the Division of Water and Land Development, Department of Land and Natural Resources.
- 1973-1976, appointed the Study Manager of the Hawaii Water Resources Regional Study by the U. S. Water Resources Council.
- 1977-1978, appointed the Executive Secretary of the State Water Commission.
- In January 1979, appointed to present position as Chief Water Resources and Flood Control Engineer with the Division of Water and Land Development, Department of Land and Natural Resources.
- Member of the American Society of Civil Engineers
  Member of the National Society of Professional Engineers
  Member of the American Water Works Association
  Member of the American Public Works Association

FEB -6

CURRICULUM VITAE

Donald Mattson Thomas

Personal

Born: 18 May 1948, Bethesda, Maryland

Education

1966–1970 Dickinson College: B.S., Chemistry, Physics (Graduated Cum Laude)

1970–1972 Oregon Graduate Center: M.S., Electrochemistry
Thesis: The Pressure Dependence of Hydrogen Absorption on a Platinum Electrode

1973–1977 University of Hawaii: Ph.D., Chemistry
Thesis: An isotopic Profile of Gases From the Summit and Flank of Kilauea Volcano

Active Research Specialization

Volcanic gas geochemistry: determination of isotopic and elemental compositions of fumarolic and eruptive gases as a means of identifying the ultimate sources of volcanic volatiles (e.g., meteoric waters, mantle outgassing, etc.), as well as a means of monitoring quiescent and eruptive processes in the volcanic pile. Also of interest are the effects of volcanic outgassing on global atmospheric budgets of natural and anthropogenic pollutants.

Geothermal exploration geochemistry: determination of chemical and isotopic composition of groundwaters and soil gases as tracers of leakage from geothermal reservoirs. The application of elemental and isotopic ratios of dissolved rare gases in the characterization of geothermal reservoirs.

Geothermal production geochemistry: interpretation of the chemical and isotopic composition of geothermal production fluids in terms of reservoir production characteristics, production aquifers/fluid sources, scaling/corrosion characteristics and potential environmental impacts.

Current Research

Western States Cooperative, Direct Heat Resource Assessment Program, Year IV, Department of Energy, Principal Investigator/Project Manager.

HGP-A Wellhead Generator Proof of Feasibility Project, Department of Energy, Principal Investigator: Geochemistry, Environmental Monitoring.

RESUME

NAME	Bill H. Chen
PRESENT POSITION	Associate Professor and Chair Computer Science and Engineering College of Arts and Sciences University of Hawaii at Hilo
EDUCATION	Ph.D., University of Rochester, 1970 M.S., University of Rochester, 1968 B.S., National Taiwan University, 1963

EMPLOYMENT EXPERIENCE

1979-present	Associate Professor and Chair, Engineering and Computer Science, University of Hawaii at Hilo
1977-1979	Geothermal Energy Project Manager, Center for Science Policy and Technical Assessment, Department of Planning and Economic Development, State of Hawaii
1977-1982	Acting Project Manager, Assistant Project Manager and Project Manager, HGP-A Geothermal Wellhead Generator Project (Total project cost - $10 million)
1975-1977	Associate Professor, Engineering and Computer Science, University of Hawaii at Hilo
1971-1975	Assistant Professor, Engineering and Computer Science, University of Hawaii at Hilo
1969-1971	Assistant Professor of Mathematics, Greater Hartford Community College
1968-1969	Research Assistant, University of Rochester
1966-1968	Teaching Assistant, University of Rochester
1964-1966	Teaching Assistant, National Taiwan University

VITAE-SUPPLEMENT

NAME:	Bill H. Chen	AGE:	41
MARITAL STATUS:	Married	DEPENDENT :	1 Son

HOME ADDRESS: 137 South Wilder Road, Hilo, Hawaii 96720

HOME TELEPHONE: (808) 935-7897

OFFICE: University of Hawaii at Hilo
1400 Kapiolani Street
Hilo, Hawaii 96720

OFFICE TELEPHONE: (808) 961-9388

OTHER EDUCATIONAL EXPERIENCES:

1. Completed a two-week course in Applied Reservoir Engineering offered by Applied Reservoir Engineering School, Oile and Gas Consultants International Inc., Newport Beach, California, May, 1974.

2. Completed a four-day course in Project Management offered by University of Hawaii College of Continuing Education and Community Service, Honolulu, Hawaii, March, 1979.

3. Completed a three-day technical training course in basic Geothermal Drilling and Completion Technology offered by Geothermal Resources Council, Albuquerque, New Mexico, March, 1980.

GEOTHERMAL EXPERIENCE IN SUMMARY:

1. Reservoir Engineer with Hawaii Geothermal Project, University of Hawaii, 1973-1977. Primary responsibility in well test equipment procurement and construction, wel tests and reservoir engineering analysis. Also participated in well drilling discussions.

2. Geothermal Energy Project Manager, State of Hawaii Department of Planning and Economic Development, 1977-1979. Primary responsibility in assisting procurement of Federal funding for (a) HGP-A Wellhead Generator Project ($10 million); (b) Statewide Geothermal Assesment ($600,000); (c) State of Hawaii Geothermal Commercialization Plan ($100,000).

3. Acting Project Manager, HGP-A Wellhead Generator Project, Jan.-June, 1978. Primary responsibility in procuring governmental permits, preparing environmental impact statement, negotiating contracts with U. S. Department of Energy, selecting engineering design

services and selecting environmental monitoring services.

4. Assistant Project Manager, HGP-A Wellhead Generator Project, 1978-1981. Primary responsibility in technical assistance on reservoir and wellhead equipment design and procurement, environmental monitoring, well workover and plant operations.

5. Project Manager, HGP-A Wellhead Generator Project, Aug. 1981-Oct., 1982. Overall responsibility in start-up operation and maintainance of the power plant.

6. Consultant to Feasibility Study on Utilizing Geothermal Energy in Sugar Processing, Amfac Corporation, Puna Sugar Company, 1979. Primary responsibility in providing well fluid estimation.

7. Consultant to Feasibility Study on Geothermal Industrial Park at Puna, Dillingham Corporation, 1980. Primary responsibility on geothermal reservoir and production estimation, geothermal heat pricing structure, and geothermal heat in papaya processing, wood-kiln processing and coffee processing.

8. Visiting Lecturer to University of Auckland Geothermal Institute, June, 1981 and Visiting Scientist to Department of Scientific and Industrial Research, Taupo, New Zealand, June-July, 1981.

9. Co-principal investigator on "Utilization of Geothermal Energy in Tropical Fruit Processing," with L. P Lopez, funded by State of Hawaii Department of Planning and Economic Development, 1982.

10. Principal investigator on "Interference and Well Test Analysis of Kapoho Geothermal Reservoir," funded by Hawaii Natural Energy Institute, 1981-1983.

11. Principal Investigator on "Scaling and Corrosion Study of Heat Exchangers using Geothermal Waste Water," funded by Hawaii Natural Energy Institute, 1983-1984.

12. Member of State of Hawaii Geothermal Advisory Committee since 1978.

13. Member of the State of Hawaii Department of Land and Natural Resources Technical Committee to designate geothermal subzones for the state, 1984.

9-1438
(1 2)

U.S. Department of the Interior
Geological Survey
Geologic Division

PROFESSIONAL/TECHNICAL PERSONNEL RECORD

1. NAME (last) (first) (initial)	2. Duty station	3. Date prepared
Jackson Dallas B.	Hawaiian Volcano Observ.	Feb. 1984

4. Birth date (month) (day) (year)	5. Classification title	Series	Grade
January 19 1933	Geophysicist	1313	13

6. List first and second scientific or technical specialties

a. Geophysical Exploration

b. Volcanology

7. Other scientific, technical, or special skills (regardless of relation to present position)

8. Education (include secondary schools)

School	Dates attended	Major and minor specializations	Degree, year or anticipated year
Univ. of Colorado	1951-53, 1956-58	Geology	B.A., 1958
Univ. of Colorado	1959-1960	Geology-Geophys.	
Colo. School of Mines	1963	Geophysics	

9. Specialized training (including postgraduate and Government courses)

10. Civil Service grades and dates Check if career employee [x]

Grade*	5	7	9	11	12	13					
Date	11/58	7/61	12/62	1/67	12/69	8/75					

*Use asterisk for any grade obtained in a management or other nonresearch capacity above GS-12

11. List or describe any information and (or) experience not covered on form that might affect career assignment

12a. Memberships in professional societies. give dates, and include significant offices h

Sigma Gamma Epsilon - 1960 to present
Society of Professional Well Log Analysts - 1968 to 1974
American Geophysical Union - 1974 to present
Geothermal Resources Council - 1979 to 1982

12b. Lectureships, symposia, invited conference participation. Give dates, nature of entry (were you sought out or did you apply to participat and level of participation.

Symposium on electrical geophysical techniques applied to geothermal exploration. Snowbird, Utah, 1977. Invited attendance; gave poster session on Coso Hot Springs, California.

12c. Committees to render scientific judgment. Include scientific review panels, editorial boards, editorships, with dates. Include the capacity which you served (chairman, subcommittee chairperson, member, observer, expert consultant, etc.).

12d. Other committees, special assignments, significant consultant roles (government and (or) industry). Name organization, group, dates, nature of contribution.

Visiting professor, University of Clermont II, Clermont-Ferrand, France. April to October 1982.

Consultant and advisor from June to September, 1982, on volcanic surveillance techniques at the French Observatoire Volcanologique de la Reunion, Indian Ocean.

2e. List inventions, patents held, techniques or nods developed or improved. Include dates.

1969-1971. Developed the technique for "dry tilt" measurements used for ground deforamtion studies at the Hawaiian Volcano Observatory. The technique is now used routinely in various volcanic areas throughout the world.

1982. Developed a new type of portable break-down tilt rod system for use at Piton de la Fournaise where all equipment must be backpacked to remote "dry tilt" sites. Because of the assymetric nature of a rod set a technique for temperature corrections to compensate for varying coefficients of expansion of individual rods was also developed.

2f. Honors, awards, recognition, elected membership. List and give dates.

Best presentation award for mining session, 38th annual International SEC meeting.

1968, Denver, CO., paper by Zohdy, A.A.R., Jackson, D.B., Mattick, R.E., and Peterson, D.L., Resistivity, seismic refraction, and gravity investigations for ground water near White Sands, New Mexico.

US Geological Survey, 1959, Special Achievement Award

US Geological Survey, 1974, Special Achievement Award

3. Career experience: (Use separate sheet, follow form below. List chronologically starting as early as necessary to include pertinent information. Include significant committee and administrative assignments.)

Dates		Brief description of work or position (if USGS, give name of supervisor and organization.)
From	To	

See attached

4. Bibliography: Use separate sheet and list all report references chronologically in USGS bibliographic style. Number each entry followed by the proper publication code: (P) published report; (M) published map; (O) open-file; (A) published abstract; (Ad) administrative report. For manuscripts "in press" give number of manuscript pages and intended publication medium. Progress reports, Work Plans and Accomplishments, and similar reports should not be included. See attached

5. Significant contributions: On single separate sheet, list your 3 most important publications in normal bibliographic style and describe the scientific significance of your contrubution to the publication; do not repeat an abstract. Do not use results of a scientific investigation which will not be published in the future. In describing each of these, include the following: a) statement of results (conclusions); b) significance of results (your feeling of worthiness); c) impact on field; d) for multiauthored papers, discuss what your actual contribution consisted of. Significant contributions which are not part of normal project work may be listed in place of a publication. Items included should be since your last promotion or within the last 5 years (whichever is shorter). This item is increasing in importance in Office and Division level meetings; it is to your own advantage to write it up as carefully and accurately as possible. See attached

6. Statement of career goals (optional)
If you wish to provide information on types of assignments, geologic specializations, additional education, geographic, or organizational locations you would like to, or plan to, have in the future or any other information having to do with your career, please write not more than 2 pages on it.

See attached

Dallas B. Jackson

13. Career Experience continued:

From	To	Nature of Work
11/58	7/61	Geologic Field Assistant, Geophysics Branch. Attended graduate school part time. Reduced data for professional geophysicists in the branch. Conducted field geophysical surveys under the guidance of a professional. Shared the responsibility for data collection, reduction, during 5 months of IGYC (International Geophysical Year Continued) on Ice Island T-3. Responsible for navigation of Ice Island T-3.
7/61	7/65	Geologist, Branch of Theoretical Geophysics and later Crustal Studies. Louis Pakiser, Branch Chief. Persons supervised -0 to 2. Well log studies of overburden to bedrock in western Nebraska, Colorado, and eastern Utah. The well log studies served as background for very deep DC resistivity studies in the western and mid-western US. Under the supervision of G.V. Keller I was responsible for geophysical survey, interpretation, and publication of the data from the western US. These data, plus other deep soundings funded by the BPA and using Arizona, Nevada, and California power grids for current sources were the first DC soundings to demonstrate the presence of a deep crustal conductor in the US.
7/65	6/67	Geologist, Branch of Regional Geophysics. Don Mabey, Branch Chief. Team member and part time principle investigator for numerous DC resistivity surveys to solve various structural and lithologic problems related to ground water distribution. Many surveys defined deep, fresh-water bodies over saline water in the Basin and Range Province. Surveys were made in numerous lithologic environments throughout the mainland US and in Hawaii. As well as studying water resources problems (all funding for these surveys was WRD) research and development on the improvement of DC resistivity sounding techniques. Schlumberger and dipole arrays, was an integral part of the electrical profiling and mapping surveys. Supervised 0-5 people. Work directed by project chief Adel Zohdy.

Dallas B. Jackson

13. Career Experience continued:

From	To	Nature of Work
6/67	6/68	Geologist, Branch of Regional Geophysics. Branch Chief Don Mabey. Principle investigator for electrical surveys in Grass Valley California area to evaluate usefullness of DC techniques to map lateral boundaries and depth of gold bearing paleochannels. This was part of a multidiscipline survey to compare the usefulness of aeromag., IP, EM resistivity, DC resistivity, gravity, and reflection seismology. DC resistivity defined lateral boundaries marginally well but defined paleo-channel depth to about $\pm$ 15% (as well or better than any other technique except refraction profiling). Project Chief Howard Oliver. Participated in the first electrical measurements over shallow geothermal targets in Yellowstone and in 2 more ground water related surveys: one in Alaska and one in Utah.
6/68	8/71	Geophysicist, Branch of Field Geochemistry and Petrology. Transferred to staff of Hawaiian Volcano Observatory. Scientist-in-charge, Howard A. Powers and later Don L. Peterson. Shared responsibility for ground deformation measurements and their inter-pretations for 3 rift eruptions and 1 summit eruption. Developed a spirit level tilt technique that allowed field tilt measurements to be made in the daytime or at night. Expanded the tilt network to cover Kilauea more thoroughly and improved the existing water-tube tilt system so measurements could be made in overcast weather. Initiated electrical studies at Kilauea by mapping thermal features with VLF EM techniques and was the principal investigator for a EM sounding survey of Kilauea's summit area that delineated a broad shallow conductor (> 1 km depth) that may be a geothermal system above a shallow magma reservoir. 0-1 person supervised.
8/71	3/73	Geophysicist, Branch of Reigonal Geophysics. Branch Chief Don Mabey. Transferred to Regional Geophysics Branch, Denver. Interpretation for publication of eruption and intrusion data collected at HVO. Modeled summit deformation data for magma reservoir depth, to map its location and depth, and studied migration patters of the reservoir. Evaluated all available deformation models for the summit (spherical source, vertical line source, tabular body, etc.) and concluded that the Mogi spherical source best explained observed deformation changes. Two satellitic magmatic chambers on the upper east rift zone were also identified. Part time work on field resistivity surveys for the ground water project; project chief Adel Zohdy. No people supervised.

13. Career Experie continued:

From	To	Nature of Work
3/73	1/78	Geophysicist, Branch of Regional Geophysics. Branch Chief Martin Kane. Principle investigator on ground water resistivity surveys in southern New Mexico to delineate areas of saline water; in eastern Washington to map basement configuration of the moscow-Pullman Basin; and unsuccessfully in western Washington to trace shallow aquifers in a complex sequence of thin, discontinuous sand and clay layers. --Shared responsibility for EM and DC resistivity surveys to target low resistivity regions related to geothermal areas in the Geysers geothermal field, California, and Long Valley, California and Raft River, Idaho. --Principal investigator for bipole-dipole and Schlumberger surveys to locate geothermal targets near Marysville, Montana and in the Bruno-Grandview area, Idaho. Principal investigator and project chief for AMT, telluric current, and DC resistivity studies at Cose Hot Springs, California to delineate the known geothermal resource and to investigate the surrounding region for new geothermal prospects. AMT proved to be the best tool in the Coso area for reconnaissance work although DC soundings best defined true resistivity values. 0-5 persons supervised.
1/78	1/82	Transferred to Hawaiian Volcano Observatory at Kilauea Volcano as a research geophysicist. Scientist-in-Charge: Gordon Eaton. Project supervisor for electromagnetic and galvanic geoelectrical studies on the island of Hawaii. --Mapped SW rift zone of Kilauea Volcano to Puu Koae delineating numerous self-potential anomalies related to geothermal phenomena. --Established and maintain numerous lines for self-potential monitoring on Kilauea Volcano. --Mapped with D.C. soundings the summit and upper rift zones of Kilauea to delineate areas of dike impounded groundwater. --Completed preliminary self-potential survey of Hualalai Volcano delineating a possible zone along the NW rift zone of geothermal potential. --Team member in an ELF (extra low freq.) loop-loop electromagnetic sounding survey of the summit and upper rift zones of Kilauea and to define the geoelectrical structure of Kilauea. --Established an electromagnetic vertical-field monitor at the summit of Kilauea to study direct sensing of magma movement and possible eruption-related precursors. --In cooperation with Hawaii Institute of Geophysics participated in a mise-a-la-masse survey to define the lateral extent of the HGP-a geothermal steam field in the Puna District.

Dallas B. Jackson

13. Career Experience continued:

From	To	Nature of Work
1/82	Present	Research Geophysicist. Branch of Igneous and Geothermal Processes. Branch Chief. Patrick Muffler. Scientist-in Charge since 1979. Robert Decker.

A portable dry-tilt system for use in highly inaccessable areas was designed and built in early 1982. The remainder of 1982 was spent in France and on Piton de la Fournaise in the Indian Ocean. A dry-tilt (spirit level) network was installed on Fournaise as the first step to setting up a ground deformation measurement program. At Kilauea ground tilt measurements are the most valuable tool to define centers of vertical displacement that may be precursive to eruptions. This has also proved to be true on Fournaise where ground displacements are negligable most of the time. The December 1983 eruption of Fournaise was preceeded by vertical uplift in the vicinity of the new eruptive fissures; precursive uplift was documented by tilt vectors before eruption began.

Principle investigator for geoelectrical studies at HVO. Research on self-potential (SP) source mechanisms at Kilauea. mapping of SP on Kilauea. Hualalai. and Mauna Loa volcanoes. Monitoring of SP changes on permanent arrays located over zones of high heat flux and continuation of a monitoring program for vertical magnetic field changes at 4 sensors located in and near the summit area. The measured magnetic fields are generated by a large horizontal source loop 1 km NW of the caldera and for convenience is called a controlled source electromagnetic monitor (CSEM).

The CSEM began in 1979 is ongoing and will be automated to an analog telemetry system in 1984. The monitor system. nearing completion. was designed and is being built at the Geophysics Branch electronics laboratory. Large CSEM anomalies have been identified related to intrusions in August 1980 and January 1981. The CSEM event in 1981 was precursive to the intrusion. Modelling experiments in December 1983 show that orthoginal horizontal coils added to the existing vertical coils at the monitor sites will increase the sensitivity of the monitors to emplacement of conductors (dikes) and may also add the capability of defining the direction to an intrusion relative to the monitor sensors.

Dallas B. Jackson

13. Career Experience continued:

From	To	Nature of Work
1/83	present-cont.	SP mapping of Hualalai volcanoe, ongoing since 1980 and to be compete in 1984, reveals high amplitude anomalies associated with the rift zone at the summit and down the NW rift zone to about the 1500 m elevation. Confirmation of the existance of a conductor coincident with the SP high at the 1800 m elevation by EM techniques and anolog to SP relations at Kilauea suggests this may be an important, exploitable geothermal resource for west Hawaii.

PROF SIONAL/TECHNICAL PERSONNEL R RD

1. Name (last)	(first)	(initial)	2. Duty Station	3. Date Prepared
Kaushikaua	James	P.	Honolulu, HI	February 1984

. Birth date (month)	(day)	(year)	5. Classification Title	Series	Grade
August	1	1951	Geophysicist	1313	12/4

6. List first and second scientific or technical specialities

a. (303) Electrical geophysics b. (603) Numerical methods for computation

. Other scientific, technical, or special skills (regardless of relation to present position)

Proficiency in computer languages - APL, FORTRAN, BASIC, PASCAL, PL/1, HP-41C language
Photography
Auto mechanics
Scuba diver
Voice, guitar, piano trained
Reading knowledge of French and German

. Educ. tion: (include secondary schools)

School	Dates attended	Major and minor specializations	Degree year or anticipated year
Kamehameha School	to 1969		H.S. Diploma
Univ. of So. California	1969-1971	Physics	
mona College	1971-1973	Geology	B.A. 1973
Univ. of Hawaii	1973-1976	Geophysics	M.S. 1976
Univ. of Hawaii	1978-1982	Geophysics	Ph.D. 1982

. Specialized training (include post-graduate and government courses)

None

10. Civil Service Grades and dates Check if career employee X

ade	GS-9	GS-11	GS12
Date	12/76	11/78	10/80

11. List or describe any information and/or experience not covered on form that might affect career assignment.

Memberships in professional societies. List, give dates, and include significant offices held.

American Geophysical Union 1979-present
Society of Exploration Geophysicists 1978-present
Geothermal Resources Council 1979-1981
Assoc. for Computing Machinery 1972-1978
Hawaii Association of Professional Geologists 1982-present

12b. Lectureships, symposia, invited conference participation. Give dates, nature of entry (were you sought out or did you apply to participate?), and level of participation.

Invited symposium speaker on "Electromagnetic exploration methods for geothermal resources", Hawaii Natural Energy Institute, April 1980.

Invited speaker on "Use of Electrical-resistivity techniques for groundwater exploration", Hawaii Water Works Assoc., May 1983.

12c. Committees to render scientific judgement. Include scientific review panels, editorial boards, editorships, with dates. Include the capacity in which you served (chairman, subcommittee chairperson, member, observer, expert consultant, etc.).

Served on U.S. Geological Survey committee reviewing the non-seismic geophysics program at Hawaii Volcano Observatory, May, 1982.

Served as a judge for Hawaii State High School Sience Fairs, 1982-1984.

12d. Other committees, special assignments, significant consultant roles (government and/or industry). Name organization, group, dates, and nature of contribution.

None

12e. List inventions, patents held, techniques or methods developed or improved. Include dates.

1977- developed a numerically stable technique for computing the coupling between two, very closely-spaced, finite length wires on a layered halfspace.

1980- developed a fast algorithm to compute EM fields about a polygonal-shaped, horizontal loop on a layered halfspace.

12f. Honors, awards, recognition, elected membership. List and give dates

Graduated cum laude, Pomona College, 1973
Awarded research assistantship, University of Hawaii, 1973-1976
Awarded USGS internship, 1977-1982

Career Experience

ᴐm	To	Nature of work
?71	1973	(exd. summers) teaching assistant for various introductory geology courses at Pomona College.
-?73	1976	Research assistant, Hawaii Geothermal Project, University of Hawaii; Doug Klein, supervisor. Application of electrical geophysical methods to geothermal exploration in Hawaii. Involved planning small surveys, field work, gathering data using the following techniques: loop-loop frequency sounding, time-domain electromagnetic sounding, Schlumberger sounding, and direct-current bipole mapping. Master's thesis reported on a newly developed method to interpret the time-domain data. These results integrated with those from other disciplines were used to locate a successful geothermal well.
..̣/76	12/77	Geophysicist, Branch of Electromagnetism and Geomagnetism, Branch Chief: Frank Frischknecht. Research involving numerical modelling of electromagnetic techniques used as geophysical tools. Derived formulas and developed computer algorithms to compute the electromagnetic fields (both time and frequency domains) about a finite-length wire, the electric field very close to a wire (in a Schlumberger array, for example), and the electric field of a grounded wire on an earth model with complex (frequency-dependent) conductivities. Applied these programs to the interpretation of electromagnetic data obtained at Randsburg KGRA in California.
:/77	12/81	Geophysicist, Branch of Electromagnetism and Geomagnetism, and Hawaii Geothermal Resource Assessment Program, University of Hawaii. Proposed, planned and supervised completion of three joint projects of (USGS and UH): 1) geothermal assessment of five selected areas on Hawaii island using a combination of time-domain electromagnetic and Schlumberger sounding techniques; 2) mise-a-la-masse experiment using a geothermal well casing as the prominent electrode; 3) investigation of the use of VLF and EM loop-loop profiling for fast regional reconnaissance of volcanic terrain.
6/78	Present	Geophysicist, Branch of Electromagnetism and Geomagnetism; Branch Chief: Frank Frischknecht, Adel Zohdy; Project: Hawaii Geothermal Investigations, Project Chief: Charlie Zablocki. Completed two- and three-component magnetic field measurements at 45 locations about a large, controlled-source loop located in the summit region of Kilauea volcano, Hawaii. The original purpose was to map subsurface magma concentrations with this technique because of its sensitivity to magma's inherently low resistivity. Compilation of layered-earth interpretations for most of these soundings together with physical scale model results, show that the entire summit region is underlain by a thin, very conductive layer less than 2 km below the surface. Magma bodies below this layer are difficult or impossible to detect with this technique. The results of this experiment were reported in a PhD dissertation, June 82.

Partly on the basis of the above resusits, an experiment to continuously monitor the summit region resistivity was begun ir March, 1979 and has continued to present. Experiment could be an important tool with which to predict volcanic eruptions because it relies on entirely different properties than conventional monitors like surface tilt and seismicity, therefore can be independent. Results have been promising enough to warrant further sophistication. A computer-controlled data acquisition system coupled with telemetry has been built and is being tested for installation in FY 84. The new system will allow more accurate data to be obtained more often with less manpower.

6/82 Present Geophysicist, Branch of Geophysics, Groundwater exploration project, Branch and Project Chief: Adel Zohdy. Overall aim was to evaluate electrical geophysics techniques for groundwater exploration in the three environments normally encountered in Pacific islands. A combination of Schlumberger and electromagnetic techniques were used to estimate groundwater reserves and the results were compared to preexisting wells to determine success of application.
Field studies to date include:
Recent volcanic terrains in the State of Hawaii, Waimea and Kona, Hawaii, Kalaupapa, Molokai, and Schofield, Oahu were studied. Several islands in Truk and the Marshalls were studied representing low-lying atolls. Finally, Guam and Saipan were host to several studies of marine limestone capped volcanic islands, known as "high" islands.
Research into appropriate interpretation methods for these environments centers around computer methods and models suited for the differing geologic conditions.

March 1984

DANIEL LUM
272 Kalalau Street
Honolulu, Hawaii 96825

EDUCATION

1956: Rice University, Houston, Texas. B.A. degree in Geology.

1957: University of Utah, Salt Lake City. M.S. degree in Geophysics.

WORK EXPERIENCE

1957-1960: Geophysicist, South Dakota Geological Survey, Vermillion. In charge of all geophysical activities of the Survey, including regional gravity studies for oil and gas and structural geology, electrical resistivity investigations for ground water development, and geophysical well logging.

1960-1984: Geologist, Head of Geology-Hydrology Section, Water Resources and Flood Control Branch.

- Project geologist and supervisor for more than 50 ground water exploration and development wells.
- Project geologist on major dam and reservoir projects.
- Responsible for numerous investigations in water resources planning and development, hydrology and mineral resources.
- Principal author and coordinator in the adoption of Hawaii State's geothermal leasing and drilling regulations in 1978.

PUBLICATIONS

Author of numerous published reports and papers, unpublished administrative reports, and technical presentations.

PROFESSIONAL MEMBERSHIPS

Geological Society of America
American Geophysical Union
Society of Exploratory Geophysicists

(7/82)

U.S. Department of the Interior
Geological Survey
Geologic Division

PROFESSIONAL/TECHNICAL PERSONNEL RECORD

NAME (last)	(first)	(initial)	2. Duty station	3. Date prep
Moore	Richard	B	Hawaiian Volcano Observ.	Feb. 1

Birth date (month)	(day)	(year)	5. Classification title	Series	Grade
July	10	1945	Geologist	GS-1350	13

List first and second scientific or technical specialties

Geologic mapping and interpretation of petro-chemical data

b. Operation of electron microprobe

Other scientific, technical, or special skills (regardless of relation to present position)

Familiarity with volcano monitoring equipment.
Operation of mass spectrometers.

Education (include secondary schools)

School	Dates attended	Major and minor specializations	Degree, year or anticipated year
Lexington MA High School	1960-63		Diploma
Tufts Univ., Medford MA	1963-67	Geology, Classics	B.S. 1967
U of North Dakota, Grand Forks	1967-69	Igneous Petrology	M.S., 19[illegible]
U of New Mexico, Albuquerque	1970-73	Igneous Petrology	Ph.D., 197[illegible]

Specialized training (including postgraduate and Government courses)

Graduate courses in geology and physical chemistry.

9. Civil Service grades and dates

Check if career employee x☐

Grade*	5	5	6	5	5	9	9	12	13	
Date	1968	1969	1970	1971	1972	1973	1974	1974	1982	

Use asterisk for any grade obtained in a management or other nonresearch capacity above GS-12

1. List or describe any information and (or) experience not covered on form that might affect career assignment

See attached

Moore, Richard B.

11. List or describe any information and/or experience not covered on form that might affect career assignment.

A. U.S.G.S. field experience includes: (1) examining ore deposits in San Juan Mts., Colo.; (2) mapping a diabase intrusion and examining uranium deposits in McKinley and Valencia counties, New Mexico; (3) mapping the late Cenozoic San Francisco volcanic field, Az., and studying its petrology; (4) assignment to Hawaiian Volcano Observatory (8/77 to 9/80), and consequent observation of eruptive activity, handling of monitoring equipment, and field geologic mapping on Kilauea Volcano; (5) mapping and petrologic studies on Hualalai Volcano (project chief); (6) mapping and petrologic studies on Sao Miguel Island, Azores (agreement with USAID).

B. Laboratory experience includes: (1) operating electron microprobe to analyze returned lunar samples and San Francisco volcanic field rocks; (2) operating mass spectrometer.

12a. Memberships in professional societies. List, give dates, and include significant offices held.

Geological Society of America	1968-present
Sigma Xi	1968-present
Sigma Gamma Epsilon	1968-present
American Geophysical Union	1971-present

12b. Lectureships, symposia, invited conference participation. Give dates, nature of entry (were you sought out or did you apply to particip and level of participation.

1. Invited guiding of field trips-GSA Rocky mt. Section Meeting, 1974 (San Francisco Volcanic Field)
2. Invited guiding of field trips-Circum-Pacific Energy Meeting, 1978 (Island of Hawai)
3. Invited guiding of field trips-IAVCEI Symposium on Volcanism, 1979 (Island of Hawaii)
4. Invited to present paper on Hawaiian volcanism, IUGG meeting in Canberra, 1979 (abstract is listed in bibliography, but I did not receive approval for foreign travel--Bob Decker presented my paper)
5. Chaired section on volcanism, GSA Cordilleran Section, 1978, Tempe

12c. Committees to render scientific judgment. Include scientific review panels, editorial boards, editorships, with dates. Include the c which you served (chairman, subcommittee chairperson, member, observer, expert consultant, etc.).

None

12d. Other committees, special assignments, significant consultant roles (government and (or) industry). Name organization, group, d s nature of contribution.

Geologist in USGS team assisting the government of the Azores in the assessment of Azorean geothermal resources, 1980-1983.

Assisted Apollo 17 crew in geologic traverses, San Francisco volcanic field, 1972.

Moore, Richard B.

13. Career experience:

From	To	
7/68	9/68	U.S.G.S. Field Assistant, supervisor Calvin S. Bromfield, Denver. Mapping of volcanic rocks in the western San Juan Mts., Colorado; collection of ore samples and stream sediments.
6/69	10/69	U.S.G.S. Field Assistant, supervisor Charles T. Pierson, Denver. Mapping and petrography of a diabase intrusion; examination of uranium deposits.
10/69	10/70	U.S.G.S. Physical Science Technician, supervisor E. W. Wolfe, Flagstaff. Mapping, petrology, and geochemistry of San Francisco volcanic field.
5/71	9/71	U.S.G.S. Field Assistant, supervisor E. W. Wolfe, Flagstaff. Mapping, petrology, and geochemistry of San Francisco volcanic field.
5/72	9/72	U.S.G.S. Field Assistant, supervisor E. W. Wolfe, Flagstaff. Mapping, petrology, and geochemistry of San Francisco volcanic field.
1967	1969	Graduate Assistant, University of North Dakota. Teaching of optical mineralogy and petrology laboratory classes.
1970	1971	Graduate Assistant, University of New Mexico. Teaching of physical geology laboratory classes.
1971	1973	Research Assistant, University of New Mexico. Analyzed lunar samples in electron microprobe for Klaus Keil and Martin Prinz.
10/73	8/77	Geologist, U.S.G.S., Flagstaff, Arizona. Project Chief: E. W. Wolfe. Mapping, petrology (including electron microprobe work), and geochemistry of San Francisco volcanic field.
8/77	9/80	Geologist, U.S.G.S., Hawaiian Volcano Observatory. Supervisors: G. P. Eaton and R. W. Decker. Surveillance of activity of Kilauea and Mauna Loa volcanoes. Field geologic mapping of part of Kilauea volcano. Petrology and geochemistry of Kilauea rocks.

Moore, Richard B.

13. Career experience (Continued):

From	To	
10/80	Present	Geologist, U.S.G.S., Hawaii. Chief of "Geology and Petrology of Hualalai Volcano" project. Supervisor--Field G & P Branch Chief. Includes 8 months studying geology and petrology of the Agua de Pau, Sete Cidades, and Furnas Volcanoes, Sao Miguel Island, Azores. I have supervised two employees. The Hualalai project will result in reports that identify volcanic hazards and potential geothermal targets on a possibly dangerous, heavily populated volcano. Ditto for the Azorean project--I am the geologist in a 6-member USGS team.

(02/10/84)

CURRICULUM VITAE

John M. Sinton

PRESENT POSITION: Associate Professor of Geology and Geophysics
Hawaii Institute of Geophysics
University of Hawaii
Honolulu, Hawaii 96822
(808) 948-7751

PERSONAL INFORMATION:

Date of Birth: April 12, 1946
Place of Birth: Bozeman, Montana
Social Security No.: 563-62-0212

EDUCATION:

A.B.	Geology, University of California at Santa Barbara, June 1969
M.S.	Geology, University of Oregon, Eugene, Oregon, September 1971
Ph.D.	Geology, University of Otago, Dunedin, New Zealand, May 1976

Theses:

M.S.	A Study of Granitization in Northern Saskatchewan
Ph.D.	Structure, Petrology and Metamorphism of the Red Mountain Ophiolite Complex, New Zealand

PROFESSIONAL EXPERIENCE:

June, 1969–Sept. 1969	Summer Field Geologist, Standard Oil Co. of California, 6/69–9/69
Sept. 1969–June 1970	Teaching Fellow, University of Oregon, Geology Dept.
June, 1970–Sept. 1970	NSF Summer Traineeship
Sept. 1970–June 1971	Head Teaching Fellow, University of Oregon, Geology Dept.
June 1971–Sept. 1971	Senior Assistant, Saskatchewan Dept. of Mineral Resources, Precambrian Division
Sept. 1971–Dec. 1975	Teaching Fellow, University of Otago, Geology Department
Jan. 1976–March 1977	Post-doctoral Fellow, Smithsonian Institution, Dept. of Mineral Sciences

PROFESSIONAL EXPERIENCE: (Contd.)

Nov. 1976-Jan. 1977	Shipboard Scientist with Deep Sea Drilling Project aboard GLOMAR CHALLENGER Leg 51
1977-Present	Research Associate, Smithsonian Institution
May 1977-July 1981	Assistant Professor, Geology and Geophysics Dept. and Hawaii Institute of Geophysics, University of Hawaii,
May 1979-June 1979	Co-chief Scientist: R/V KANA KEOKI, Cruise KK78-12, Leg 05, Galapagos Ridge
July 1980	Chief Scientist: R/V KANA KEOKI, Cruise KK80-07, Musicians Seamounts,
July 1981-Present	Associate Professor, Geology and Geophysics Dept. and Hawaii Institute of Geophysics, University of Hawaii
April 1982	Shipboard Scientist, R/V KANA KEOKI, Cruise KK82-03, Melanesian Borderland
April 1983	Scientific Observer, Research Submersible MAKALII, Dives 83-157 and 83-159.

SOCIETIES:

American Geophysical Union

APPENDIX D

PUBLIC REQUEST FOR INFORMATION

LEGAL NOTICE

PUBLIC NOTICE

REQUEST FOR GEOTHERMAL RESOURCE INFORMATION

The Department of Land and Natural Resources is in the process of assessing geothermal resource development areas in the State of Hawaii as mandated by Act 296, SLH 1983. In order to maximize the base of available information, the Department invites any person or organization to submit any pertinent information to assist in the assessment.

Information may include, but need not be limited to:

(1) Areas with geothermal resource development potential to develop electrical energy.
(2) Geologic hazards that may be encountered in geothermal resource development.
(3) Social or community impacts that may arise from geothermal resource development.
(4) Economic impacts that may result from geothermal resource development.
(5) Environmental impacts that may be encountered from geothermal resource development.
(6) Any other related information that may be considered in the subzoning of geothermal resource development areas.

The information should be sent to the Division of Water and Land Development, Department of Land and Natural Resources, P.O. Box 373, Honolulu, Hawaii 96809, or delivered to the Division of Water and Land Development office at 1151 Punchbowl Street, Room 227, Kalanimoku Building, Honolulu, Hawaii, by May 21, 1984.

BOARD OF LAND &
NATURAL RESOURCES
SUSUMU ONO
Chairperson of the Board

Dated: April 10, 1984
(S.B.: Apr. 16, 18, 1984) (SB-5279)

State Ex. No. 10

ENVIRONMENTAL IMPACT ANALYSIS
OF
POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-106

State of Hawaii

DEPARTMENT OF LAND AND NATURAL RESOURCES

Division of Water and Land Development

EXHIBIT NO.	DESCRIPTION
3	Circular C-100, Geothermal Resource Developments
4	Circular C-97, Plan of Study for Designating Geothermal Resource Subzones
5	Circular C-98, Assessment of Available Information Relating to Geothermal Resources in Hawaii
6	Circular C-103, Statewide Geothermal Resource Assessment
7	Circular C-99, Public Participation and Information Program for Designating Geothermal Resource Subzones
8	Circular C-104, Social Impact Analysis of Potential Geothermal Resource Areas
9	Circular C-105, Economic Impact Analysis of Potential Geothermal Resource Areas
10	Circular C-106, Environmental Impact Analysis of Potential Geothermal Resource Areas
11	Circular C-108, Geothermal Technology
12	Circular C-107, Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas
13	Proposal for Designating Geothermal Resource Subzones by the Board of Land and Natural Resources
14	A Report on Geothermal Resource Subzones for Designation by the Board of Land and Natural Resources

Dated: Honolulu, Hawaii, December 7, 1984

Robert T. Chuck

ROBERT T. CHUCK
Manager-Chief Engineer

BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

In the Matter of the Designation of Kahaualea, Puna, Hawaii as a Geothermal Subzone	G.S. No. 8/27/84-1

EXHIBIT LIST

EXHIBIT NO.	DESCRIPTION
1-A	Highlights of Act 296, SLH 1983
1-B	Assessment Factors
1-C	Highlights of Act 151, SLH 1984
1-D	Technical Committee
1-E	Geothermal Resource Assessment
1-F	Examination of Concerns: (Social, Economic, Environmental, Hazards and Compatibility)
1-G	Hawaii State Planning Act, Chapter 226
1-H	Kilauea Upper East Rift: Assessment Factors
2-A	Potential Geothermal Resource Areas
2-B	Kilauea Upper East Rift: State Land Use Zoning Map
2-C	Kilauea Upper East Rift: Land Ownership Map
2-D	Kilauea Upper East Rift: Lava Flows Map
2-E	Kilauea Upper East Rift: Vegetation Map
2-F	Kilauea Upper East Rift: Essential Endangered Species Habitat Map
2-G	Kilauea Upper East Rift: Rainfall Data Map

ENVIRONMENTAL IMPACT ANALYSIS
OF
POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-106

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
October 1984

GEORGE R. ARIYOSHI
Governor

BOARD OF LAND AND NATURAL RESOURCES

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Board of Land and Natural Resources

EDGAR A. HAMASU, Deputy to the Chairperson

ROBERT T. CHUCK, Manager-Chief Engineer
Division of Water and Land Development

PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which address each of the subzone designation factors. This report analyzes the major environmental impacts that may result from geothermal development. Impacts include risks to people and property as well as wildlife and plant life. The effect of various natural factors such as wind and rain are included. Land use compatibility and impact mitigation measures are also described.

Preparation of this report was coordinated by Sherrie Samuels, Planner, with the assistance and under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development (DOWALD), Department of Land and Natural Resources.

DOWALD staff members, engineers George Matsumoto, Thomas Nakama, and Neal Imada, and geologists Daniel Lum and Ed Sakoda, have made significant contributions throughout this report. Paul Haraguchi of Pacific Weather, Inc. prepared the section on meterology and Lee Hannah of the University of Hawaii Environmental Center prepared the section on flora and fauna.

CONTENTS

CONTENTS (Continued)

TABLES

<u>FIGURES</u>

SUMMARY

This report addresses potential environmental impacts to flora and fauna, surface and ground water resources, ambient air quality, and ambient noise levels, historical and archaeological resources, and scenic and aesthetic values. The characteristics and effects of local and regional meteorology are also considered.

The compatibility of geothermal development with existing land uses and zoning is examined. Evaluation of each resource area provides the conclusion of the study.

Meteorology. Meteorology, in general, and winds, in particular, are very important in geothermal operations because of their effect on emissions and noise. While tradewinds are prevalent, both tradewind temperature inversions and ground temperature inversions affect the movement of air in and over geothermal resource areas.

Flora and Fauna. One of the more serious environmental impacts is the potential disruption of native forest ecosystems. Two indicators were used to assess impact--native habitat importance and forest quality. Native habitat importance was defined by the presence of endangered species since this factor correlates well with the value of an area to native fauna in general. The relative value of a native forest was assessed using a three-part categorization system based on the percent of canopy provided and the quality of native forest present, the assumption being that undisturbed closed canopy, native forest would be the most susceptible to disruption by geothermal development.

Of Hawaii's seven plant species which are formally listed as endangered, only one, Hawaiian vetch, was found in a geothermal resource area. The presence of an endangered species was used as an indicator of environmental sensitivity. Protection of other rare native plants, not listed as endangered, is to be undertaken on a case by case basis in siting geothermal facilities in the future.

Surface Waters. Environmental impacts to surface waters resulting from geothermal development are expected to be minimal. None of the geothermal resource areas contain perennial streams and geothermal fluids will be disposed of by reinjection.

Groundwater. Groundwater occurs as perched, dike and basal water in geothermal resource areas. Groundwater resources will not be effected since geothermal wells are drilled past groundwater aquifers and well casings are set and cemented through a competent subsurface formation below the basal water lens. All drilling, casing installation, maintenance and abandonment of geothermal wells and reinjection wells will be regulated and monitored to protect the groundwater aquifer.

Air Quality. The assessment of air quality impacts resulting from geothermal development required examination of ambient air quality along active rift zones, emissions from geothermal wells and power plants and the current level of geothermal emission abatement technology.

Geothermal developments in Hawaii will be required to have abatement systems that meet the proposed State Department of Health air quality standards. At present, the recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the non-condensable gases. Use of this system would enable facilities to comply with the proposed air quality standards that require 98% of the H_2S present to be removed.

It should be noted that due to the sulfur content of fuel oil, oil-fired power plants may emit at least ten times more sulfur dioxide per megawatt-hour than would a geothermal power plant. Therefore, replacement of oil-fired power plants with geothermal power plants may reduce the overall impact to the environment and air quality.

Historic and Archaeological Values. Geothermal development may potentially degrade remaining cultural and archaeological values by site clearing and facility construction. Literature searches, plotting of known sites and on-site archaeological reconnaissance surveys should be utilized to assess potential impacts; adjustment of facility siting to avoid archaeologically sensitive areas will mitigate potential impacts.

Noise. During the initial phases of geothermal development persons in the vicinity of a geothermal facility construction site will be exposed to noise levels varying from 40 to 120 decibels depending upon the distance from the site. High noise levels are produced by well drilling, production testing and well bleeding before connection to the generator. Use of accoustical baffling and rock mufflers will effectively muffle noise. Construction of rock muffler at the existing HGP-A well has reduced noise level to 44 decibels at the facility fence line.

Compliance with County of Hawaii noise guidelines will limit noise levels for geothermal activities to 45 decibels at night and 55 decibels during the day.

Scenic and Aesthetic Values. Most geothermal resource areas are located in remote, often heavily forested areas, however in some areas, development of geothermal facilities may result in visual intrusions depending on an observer's view point. Site clearing, temporary presence of drilling rigs, permanent power plant structures with 50-60 foot high cooling towers, fluid transmission lines, electrical transmission lines, and periodic steam plumes above the development site are possible sources of visual intrusions. Appropriate mitigation measures may help to minimize visual impacts, however, some impacts such as steam plumes will remain.

Land Use Zoning, Existing Land Uses and Land Use Compatibility. Act 296, in addressing the designation of geothermal resource subzones, requires assessment of each geothermal resource area by an examination of various factors including the compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under Section 205-2 Hawaii Revised Statues, relating to State Land Use Districts, Section 183-41, HRS, relating specifically to Conservation Districts, and all uses permitted under County general plans or land use policies.

Act 296 also allows geothermal resource subzones to be designated within any of the four state land use districts established under Section 205-2 of the Hawaii Revised Statutes. As such, geothermal facilities could be located adjacent to any of the land uses existing or permitted in the four state land use districts.

The State Land Use Districts found in each of the potential geothermal resource rift zones are:

Kilauea East Rift Zone - Conservation, agricultural, and urban districts.

Kilauea Southwest Rift Zone - Conservation, agricultural, and urban districts.

Mauna Loa Southwest Rift Zone - Conservation and agricultural districts.

Mauna Loa Northeast Rift Zone - Conservation and agricultural districts.

Hualalai Northwest Rift Zone - Conservation and agricultural districts.

Haleakala Southwest Rift Zone - Conservation and agricultural districts.

Haleakala East Rift Zone - Conservation, agricultural, urban, and rural districts.

Actual land uses in geothermal resource areas although characteristic of their respective zoning, may vary considerably. As noted above, most geothermal resource areas contain conservation zoned land that includes forest reserve, national and state parks, other forested areas, brush and grass lands, and barren lava flows. Often conservation zoned lands provide habitat for native and rare or endangered species as well as hunting area, and watershed lands.

Potential subzone areas zoned agricultural are used mostly for livestock grazing.

Rural areas are characterized by low density residential uses on one-half acre lots and are often intermixed with small farms.

Urban areas include residential and commercial uses.

Some negative aspects, such as visual intrusions, are expected in developing geothermal resources; however, proper mitigation of undesirable characteristics can achieve greater compatibility.

In each resource area, both positive and negative aspects and possible mitigation were considered in assessing land use compatibility.

Evaluation of Impacts in Potential Geothermal Resource Areas

Evaluation of impacts was accomplished by reviewing available information for each geothermal resource area. Information on local meteorology, surface and ground water, underground injection control areas, existing land use and zoning, flora and fauna, historic and archaeological sites was systematically mapped and each area evaluated in terms of anticipated environmental impact.

Lower Kilauea East Rift Zone:

Development of geothermal resources in the Lower East Rift Zone has been underway since 1973-74 with the issuing of geothermal resource mining leases for four areas, designated GRML R-1, R-2, R-3, and R-4. Development of additional sites in the Lower East Rift zone will not impact any essential endangered species habitat, but may impact existing communities in terms of noise and aesthetics. The provision of a buffer zone will help to mitigate such impacts. Air Quality will not be impacted, since it is expected that given current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

Upper Kilauea East Rift Zone:

Development of geothermal resources in the Kilauea Upper East Rift zone will be limited to areas outside the Hawaii Volcanoes National

Park. Air quality within surrounding areas will not be impacted given the current level of abatement technology.

Site development may impact endangered o'u habitat; however, as stated in the Kahauale'a Environment Impact Statement (June 1082), "the minimal removal of vegetation and trees within the Kahauale'a project area should not significantly threaten the O'u."

Kilauea Southwest Rift Zone:

Development of geothermal resources in portions of the Kilauea Southwest Rift Zone, outside the National Park, would probably result in minimal environmental impact.

Development proximity to the Pahala and Punaluu communities may result in aesthetic impacts, however, air quality will not be impacted.

Mauna Loa Northeast Rift Zone (Kulani):

Development of a geothermal resource in areas other than the cleared grazed agricultural area in this rift zone may impact the four endangered forest bird species and the Nene by disturbing essential habitat areas.

Mauna Loa Southwest Rift Zone (Kahuku Ranch):

Development of geothermal resources in the lower, agricultural-zoned portion of the proposed subzone may result in minimal environmental impact provided a buffer area is maintained between the geothermal development site and the Hawaiian Ocean View Estates.

Hualalai Northwest Rift Zone:

Development of geothermal resource in areas other than the grazed agricultural zoned portion of the subzone may impact the endangered species known to exist within the rift zone area. Alala, the Hawaiian Crow, is reported to number fewer than 20 individuals.

Disturbance of their Hualalai habitat may cause further decline of this species, or its extinction.

Haleakala Southwest Rift Zone:

Development of geothermal resources within the grazed agricultural zoned portions of the rift zone will result in minimal impact to fauna since no endangered species habitat is present.

Proximity to the Makena residential and resort development, Ulupalakua Ranch and upslope, the Haleakala "Science City" may be affected aesthetically. Air quality in urbanized areas will not be impacted since it is expected, given the current level of technology, that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal resource development.

Haleakala East Rift Zone:

Development of a geothermal resource in the Haleakala East Rift Zone in areas other than the grazed agricultural lands below the 1000-foot level may impact native forest bird habitat and above 4200 feet, endangered forest bird habitat. However, development of a geothermal resource below the 1000-foot level in grazed agricultural land could place a geothermal well and power plant as close as 7000 feet from the center of Hana Town. Quite clearly, the rural lifestyle of the Hana Community would be affected.

INTRODUCTION

Act 296, Session Laws of Hawaii 1983, requires that environmental impacts be considered when the Board of Land and Natural Resources designates subzone areas for the development of geothermal resources. This report addresses the major environmental impacts that are likely to result from geothermal development.

Environmental impacts are described generally; the effects of various natural factors such as wind and rain are included. Impacts include risks to people and property as well as to wildlife and plant life. Impact mitigation is also described and each resource area is evaluated.

METEOROLOGY: DESCRIPTION AND EFFECT

Climatological elements deemed important in assessing environmental impact in geothermal rift zones include rainfall, temperature, winds, trade wind inversions, and ground temperature inversions. Cloudiness, solar radiation, and relative radiation are not considered important elements in geothermal development and in Hawaii data for these factors are not available for areas within rift zones.

AIR TEMPERATURE

Air temperature decreases by approximately 3°F for each 1,000 feet rise in elevation in the Hawaiian Islands. This relationship is seen in Figure 1 where the heavy slanted line (towards the left or colder temperature) has a decrease in temperature of 3°F per 1,000 feet elevation rise. The horizontal lines represent the range of the average maximum and minimum temperatures at the different locations. For example, Haleakala Rangers Station at 7,030 feet elevation has a minimum temperature of 44°F and a maximum temperature of 63°F.

WINDS

The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise. The most common winds over the Hawaiian Islands are the trade winds from the east which account for about 70% of the winds in the Islands. Figures 2a and 2b show the mean pressure and wind flow of the Pacific Anticyclone in the Eastern and Central North Pacific for January and July, the months representing the opposite seasons for winter and summer. The mean charts show the dominance of the high and outflowing trades in the Eastern and Central North Pacific especially in the summer. The mean trade wind pattern is a smooth version of the actual happenings. At any given time, the wind flow is not as static as it appears in the mean charts because the high, the source of the trades, is not as static, especially in the winter.

Over the Hawaiian Islands, the trades prevail over 90% of the time from June through August and only 40 to 60% of the time from January through March. During summer, the trade winds can persist through an entire month while during winter trade winds are sometimes absent almost an entire month. The reason for the high frequency of the trade winds during the summer is that the Islands are in the belt of the almost persistent trade winds from the Pacific Anticyclone. During winter, the mean position of the high is further south of the summertime position and the high is not as strong or as persistent. Interruptions in the trades over the Islands are much more frequent in winter than summer with the intrusions of low pressure systems displacing the high pressure area from the Islands or the high pressure area moves far away from the Islands. These are the times that non-trade winds mainly in the form of light and variable winds or light southerly winds occur in the Islands.

Winds over the rift zones are explained with limited data. There are a few wind summaries in or near the rift zones which were used but the main source of the material for the wind discussion was the knowledge of the behavior of the trade winds and the theory of the sea breeze and mountain breeze (local upslope and downslope winds).

Earlier written articles by others were also utilized in the formulation of the wind patterns over the rift zones.

TRADE WIND TEMPERATURE INVERSION

A temperature inversion is a layer in the atmosphere in which the air warms with increase in altitude which is the inverse of the normal temperature decrease through the atmosphere. Figure 3a shows an example of the vertical air temperature profile with a temperature inversion at 6,000 feet altitude.

The trade wind temperature inversion occurs about 70% of the time over the Hawaiian Islands caused by the sinking of the air at the level of the inversion from the high pressure area north of the Islands. The trade wind temperature inversion is generally persistent in space and time when it occurs. Its mean height above sea level is between 6,000 and 8,000 feet. Normally, it ranges in height between 5,000 and 9,000 feet. It occurs more often during the summer months than during the winter months. Its strength as measured by the temperature increase in the layer of the inversion from its base to its top, varies from no temperature increase through the layer to an increase of several degrees (°F) through the layer. The trade wind temperature inversion can be measured twice a day (2:00 am and 2:00 pm) in the radiosonde data at Hilo and Lihue Airports by the National Weather Service.

GROUND TEMPERATURE INVERSION

The cooler drainage air from the mountain tops flowing down the slopes and the radiational cooling of the ground at night can produce temperature inversion over some of the rift zones (Fig. 3b). The strength of this inversion in temperature is probably only a few degrees (°F) increase in temperature through a shallow layer of a few hundred feet. The inversion will break down by the heating of the land by the sun in the morning. The important conditions for the formation of the ground temperature inversion are:

1. clear night and few or no low cloud cover

2. low or no winds
3. stable atmosphere
4. cool air draining down from the higher slopes

The conditions that are against the formation of the ground temperature inversion are:

1. overcast low clouds
2. windy conditions
3. unstable atmospheric conditions, rain
4. no drainage wind flow

FLORA AND FAUNA

One of the most serious potential impacts of geothermal energy development in Hawaii is the disruption of native forest. Air pollution and groundwater impacts of geothermal development may be substantially avoided by requiring full control technologies; impact on native forest ecosystems can be mitigated through careful siting (EPA, 1978). Siting to avoid damage to biologically valuable forest can prevent both degradation of the forest due to invasion of weed species and disturbance of native bird species due to human activity and noise.

Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas (Carlquist, 1970). Once such ~~as~~ an invasion begins, native forest is gradually altered, and non-native species, which initially invaded along relatively narrow corridors, spread and multiply (Corn, 1984). Major geothermal development, with an attendant network of roads and construction corridors, may be expected to dissect and eventually degrade undisturbed native forest by opening it to invasions by weedy species.

Geothermal development may also be expected to have negative impact on native forest birds, including many which are endangered. Construction noise and human activity are factors which favor urban nuisance species over native forest species (Berger, 1972). It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal energy development. Any development within the habitat of native birds will have potential environmental impact and should be fully investigated and mitigation measures implemented.

In selecting areas in which geothermal development will have the least environmental impact, it is therefore useful to assess both forest quality and native bird habitat. Those areas with mature native forest and significant native bird habitat will tend to be the most environmentally important, while those without native bird habitat and with less intact forest will be substantially less impacted. For this study, two indicators were used to distinguish, on a broad scale, areas of high and low potential environmental impact. The indicators chosen were native habitat importance and forest quality.

The indicator chosen to depict the value of an area to native fauna is the presence of endangered species. While under some circumstances a simple survey for endangered species is an unacceptably superficial form of environmental assessment, in the present situation the presence of endangered species correlates quite well with the value of the area to native fauna in general. Relative value of native forest has been assessed using a categorization system developed by the University of Hawaii Environmental Center based on forest type mapping done by the United States Fish and Wildlife Services (Jacobi, 1983). This system indicates areas in which geothermal development would have the greatest environmental impact, areas in which geothermal development would have little or no impact on valuable native forest, and areas in which the impact of geothermal development on native forest is uncertain. Map overlays were prepared to illustrate the distribution and intersection of essential habitat and forest quality factors.

Endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are plans of action for restoring the population of a species pursuant to its listing as endangered by the Secretary of the Interior. Recovery plans are drafted by teams of wildlife experts from both state and federal agencies, and represent estimates of the range and life requirements of endangered species by the foremost experts in the field. Essential habitat outlined in an Endangered Species Recovery Plan is therefore almost without exception the most authoritative estimate of the actual habitat for a particular endangered species. Where no essential habitat has been designated, distribution was determined from population surveys conducted by the U.S. Fish and Wildlife Service or other available information (Scott, 1984). Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow (Alala) on the island of Hawaii and for the Nene on both Maui and the Big Island. Essential habitat has not been determined for the endangered Maui forest birds, and therefore U.S. Fish and Wildlife Service population counts were used to determine habitat boundaries for these species.

The potential for environmental impact on the flora of the resource areas was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping. The U.S. Fish and Wildlife Service system incorporates information on extent of canopy cover, height of canopy, understory composition, and vegetation association type (Jacobi, 1983). Vegetation information has been assembled and mapped by the Service using this system for large portions of four of the five main Hawaiian islands, including Maui and Hawaii. Information in this form was available for all or portions of each of the resource areas. Areas not covered were lower Hana, lower Makena, Kilauea S.W. Rift, and Lower Puna. In these areas aerial photo interpretation was used to estimate vegetation type, and in high resource potential areas this aerial interpretation was verified on the ground from readily accessible roadways wherever possible. Lack of access routes made ground verification for the Kilauea S.W. Rift site impractical. The boundaries delineated on the aerial photographs were transferred to orthophoto quadrangles and assigned a vegetation type code following the USFWS system (Jacobi, 1983). Vegetation type data was then ranked according to potential for impact from geothermal development into one of three categories described below.

FLORA

Vegetation type data from U.S. Fish and Wildlife Service mapping or the present study were abstracted into a simplified, three category impact sensitivity classification system (see appendix A). The three categories of this system, which was developed by the University of Hawaii Environmental Center, and based on the assumption that undisturbed, closed canopy forest would be most susceptible to disruption due to geothermal development, are as follows:

CATEGORY 1 - Exceptional native forest;
closed canopy, over 90% native cover

CATEGORY 2 - Mature native forest;
over 75% native canopy

CATEGORY 2A - Native scrub or low forest

CATEGORY 3 - Cleared land; non-native forest;
bare ground or lava

In this system, Category 1 forests are presumed to be areas in which geothermal development would unquestionably result in environmental impact, and Category 3 lands presumed to be areas in which geothermal development would have little or no impact. Category 1 forest is vulnerable because of its high native composition, which indicates that it is virtually undisturbed, and because of its closed canopy, which indicates that any development activity would result in changes in forest structure. Category 3 lands are assumed to be of little biological value owing to high degrees of disturbance or low percentage of ground cover. Category 2 is comprised of areas which did not meet the rigorous standards of Category 1, but are not so heavily disturbed or sparsely vegetated that it can be assumed that development would not result in environmental impact. Category 2A represents areas in which the vegetation is predominantly native, but the tree layer is low and scattered and does not warrant the designation of forest. In wet forests, Category 2A vegetation is a sign of disturbance, but in dry regimes, particularly at altitude or along the coast, it is a healthy native ecotype. Both Category 2 and 2A are then classifications which convey that additional information is needed before it can be assumed that geothermal development would have little environmental impact.

The additional information needed to assess the biologic value of Category 2 forest pertains to forest diversity and the presence of rare plants. These factors were not included in the present assessment because this information is not available in any comprehensive form on such a broad scale. Information on species diversity is similarly unavailable in any readily accessible form. Because of these limitations of information availability, it is difficult to arrive at an objective classification for potential for impact by geothermal development for many forest types. There are unquestionably many excellent forest areas that have been placed in Category 2 because they fell just short of 90% native composition. There are equally certainly areas assigned Category 2 which are of little biological interest. Within these extremes, the majority of Category 2 forests are areas for which the USFWS vegetation type code tells only a part of the story, and diversity and rare plant information is required to discern the exact value and vulnerability to disturbance of the area. In the absence of a compelling reason to develop these areas, a reasonable assumption is that they are valuable and should not be disturbed. Where there is compelling reason to consider development, field reconnaissance of individual areas will be required to determine what, if any, level of environmental impact would result from development. Similar considerations apply to Category 2A areas. Vegetation types are assigned to Category 2A based on growth form, not biological value or environmental impact considerations. However, it may be worthwhile to emphasize that in wet areas at intermediate elevations, Category 2A usually represents a disturbed area or recent lava flow.

In summary, Category 1 areas are those in which substantial environmental impact can be expected to result from geothermal development, Category 2 and 2A areas are those in which geothermal development should be assumed to result in environmental impact in the absence of additional information, and Category 3 areas are those in which geothermal development may be expected to have little or no environmental impact.

Clearly the environmental advantage lies in developing within Category 3 areas. It is also worthwhile to note that environmental impact, especially on native forest birds, may result from development immediately adjacent to Category 2 areas or endangered species habitat, even if the site is Category 3, if it is in close enough proximity for noise or pollution to carry to the forest. In these instances, buffer zones can be utilized to mitigate any impact which may occur.

Rare Plants

Of Hawaii's seven plant species which are formally listed as endangered, only one, the Hawaiian vetch (Vicia menziesii) is found within the resource areas (see Figure 4). However, Hawaii has numerous rare plants, over 800 of which have been proposed for listing as endangered. Undoubtedly many of these candidate species may be found within the resource areas. For example, the endemic Hawaiian fern, Adenophorus periens, is known to be present in the Kahauale'a section of the Kilauea East Rift Zone.

Currently available information on rare species does not permit a comprehensive inventory of these species and their location, and therefore has not been addressed in this study. Protection of rare plant species will have to be undertaken on a project-by-project basis, where botanical surveys of specific areas being considered for development are possible. The forest categories presented in this study do not relate to endangered plant species presence. It should not be assumed that Category 3 areas will contain no rare plant individuals. Isolated rare native species are not uncommonly found in disturbed, non-native surroundings. Such individuals should be identified and protected, but the scope of the present study precluded such detailed analysis. Areas with high concentrations of rare plants are biologically valuable, and the presence of rare plants is one criteria which should be used in determining the potential impact of geothermal development in Category 2 areas. For example, the

Category 2 forests in the southwest quarter of the Mauna Loa East Rift area are the home range of Vicia menziesii and should therefore be considered very sensitive to environmental impacts, despite the fact that the forest type alone does not warrant ranking them in Category 1. Other areas such as this definitely exist within Category 2, and this is one reason why it is important to more completely characterize these areas before their sensitivity to impact is assigned.

FAUNA

Forest birds found in the resource areas include the I'iwi, Apapane, Elepaio, and others. The specific native forest birds present at a site are not as important as the relative value of the area as native bird habitat in general. Most native birds share habitat to some degree, and it is this characteristic which permits use of the existence of endangered bird habitat as an index of overall native bird habitat value. Because the list of native birds in the resource areas is long, discussion here will focus only on the endangered fauna found in the resource areas.

Federally designated threatened or endangered fauna within the resource areas include seven forest bird species, two seabird species, the Nene, the Hawaiian Hawk (Io) and Crow (Alala), and Hawaii's only resident mammal, the Hawaiian Hoary Bat. These species and their treatment in the resource area overlays are outlined below.

'Alala (Corvus tropicus) - One of the most critically endangered species in the United States. Population estimate 10-50 birds in the wild. Last field census reported 7 birds. Essential habitat identified, intersects majority of Hualalai resource area and flanks Kahuku Ranch resource areas (DLNR, 1984).

Hawaii Forest Birds - Includes the Hawaii Creeper (Loxops maculatus mana), Hawaii 'Akepa (Loxops coccineus coccineus), Akiapola'au (Hemignathus wilsoni), and 'O'u (Psittirostra psittacea). All are moderately endangered, with populations in the high 100's or above, except the 'O'u, which is relatively rare and has a much smaller population. Essential habitat common to all four species has been identified, and intersects all of the East Mauna Loa Rift area, most of Hualalai and Upper Puna, and flanks Kahuku Ranch (USFWS, 1982).

Maui Forest Birds - Includes Crested Honeycreeper (Palmeria dolei), Maui 'Akepa (Loxops coccineus), Maui Parrotbill (Pseudonestor xanthophrys). Essential habitat not yet identified. Distribution determined by USFWS, intersects upper Hana (Scott, 1984).

Nene (Branta sandwicensis) - Moderately endangered, maintained by captive breeding. Essential habitat identified, intersects all of East Mauna Loa Rift, most of Hualalai, and the upper elevations of Kahuku Ranch (USFWS, 1983). An upland bird adapted to sparse vegetation the Nene may be less sensitive to the presence of geothermal development than other native birds.

Hawaiian Hawk (Buteo solitarius) - Relatively common over a wide range. No essential habitat established. Known nesting sites established by USFWS lie mainly in Lower Puna and East Mauna Loa Rift, but nesting observations are far from exhaustive and lie mainly along roadways and other accessible areas (Griffin, 1984).

Hawaiian Dark-Rumped Petrel (Pterodroma phaeopygia sandwichensis) - Primary nesting colonies on Maui, outside of resource areas. Also observed within Napau Crater in Volcanoes National Park (USFWS, 1983).

Hawaiian Hoary Bat (Lasiurus cinereus semotus) - A poorly characterized species (Kepler and Scott, 1980). No know roosting sites within resource areas. Most frequently observed in non-native vegetation. Impact of development on foraging habitat uncertain, possibly minimal.

Newell's Manx Shearwater (Puffinu puffinus newelli) - Classified as threatened. No known nesting colonies within resource areas. May occasion Upper Puna and East Mauna Loa Rift (Jacobi, 1984). Impact of development uncertain, may be minimal.

Figure 5 provides sketches for reference for the species named above.

Invertebrates

Rare invertebrates known to exist in the resource areas include scientifically important fruit flies (giant Drosophila spp), tree snails (Partulina spp), and special cave-adapted fauna residing in lava tubes. The giant Drosophila species, focal point of important genetic research, are found in the Mauna Loa East Rift and Hualalai areas, and at upper elevations at Hana and Kahuku Ranch (Carson, 1984). Tree and land snails, many of which, like other Hawaiian invertebrates, are found nowhere else in the world, are associated primarily with native forest and probably exist in all resource areas.

Cave-adapted fauna might be found in lava tubes underlying any resource area, but are known to exist in Mauna Loa East Rift and Kilauea East Rift. These lava tube ecosystems are dependent on intact penetrating ohia root systems for their moisture supply, and are vulnerable to any development which results in forest clearing. While invertebrate species often receive less attention than vertebrate fauna, they comprise an important part of native ecosystems. Impacts on these species may be largely avoided by avoiding siting in native forest areas.

SURFACE WATER IMPACT

Geothermal development activities should not directly affect surface water ~~existing land uses~~ since there are no surface streams located in the rift zone ~~recommended~~ areas. While drilling and construction phases of geothermal development may be a cause of concern, little or no environmental impacts are expected. However, if surface water becomes available, accidental pollution of streams should be prevented by use of adequate and safe disposal methods of geothermal brine.

Following initial development of the geothermal resources, the production of potentially valuable associated geothermal products--demineralized water and mineral salts--could have beneficial environmental consequences. From a resource point of view, their development is desirable and should be considered. However, then recovery and production of byproduct mineral salts from geothermal brines is not economically feasible, adequate and safe disposal by reinjection will be utilized.

Almost all geothermal fluids have a total dissolved solids content greater than 1000 ppm, and their indiscriminate discharge into streams, ponds, and watersheds should not be allowed. The normal disposal practice is expected to be by reinjection. In some cases it is possible that byproduct fluids may be of satisfactory quality to be disposed of without treatment. Surface disposal, in these case, could be allowed under controlled conditions.

Environmental impacts on surface waters resulting from the development of geothermal resources in the prospective geothermal subzones are expected to be minimal. None of the subzones under consideration contains perennial streams. One, the Haleakala East Rift Zone in Maui, contains a small intermittent stream and the headwaters of several other intermittent streams that exit the subzone at their upper reaches.

GROUNDWATER HYDROLOGY

Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water.

Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations (Figure 6).

Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes water is held between the dikes to a height of more than 2,000 feet above sea level.

Basal water occurs most commonly in the islands. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. In the areas considered, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the groundwater aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions, and alternate safe disposal methods should be developed.

KILAUEA EAST RIFT ZONE

Ground water occurs as dike water and basal water in the Kilauea East Rift Zone. The only known perched water exists north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic gradients along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone on ground water movement. The effectiveness of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels (Figure 7).

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 19,000 mg/l. Because of the effects of mixing, most ground water at [illegible] is brackish. Salinity and temperature vary greatly north [illegible] south of the rift zone are

Table 6. SUMMARY OF DRAFT REVISIONS/ADDITIONS TO DEPARTMENT OF HEALTH ADMINISTRATIVE RULES, CHAPTER 11-59

Chapter 11-59-4, Ambient Air Quality Standards:

- o rule limits the time averaged concentration of specified polluants dispersed or suspended in the ambient air.
- o limiting concentrations for a twelve-month period or a calendar year shall not be exceeded.
- o limiting concentrations for one-hour, [illegible]

Section 11-60-23.2 defines geothermal power plants and sets standards for hydrogen sulfide. Hydrogen sulfide emissions from a power plant shall not exceed two pounds per one hundred pounds of hydrogen sulfide in the incoming geothermal resource. The maximum allowable increase in hydrogen sulfide concentration in the ambient air above natural background level shall be thirty-five micrograms per cubic meter as a one-hour average. The maximum allowable increase may be exceeded once per twelve-month period at any one location. Permits to construct and operate a power plant are required.

Section 11-60-19, Prevention of Air Pollution Emergency Episodes, is designed to prevent excessive buildup of air contaminants during air pollution episodes. Episodes are classified as an air pollution alert, air pollution warning, or an air pollution emergency. Maximum concentrations for each level, alert, warning and emergency are set for sulfur dioxide, particulate matter, combined sulfur dioxide and particulate matter, carbon monoxide, ozone, nitrogen dioxide and hydrogen sulfide. Appendix B specifies these concentrations.

NOISE IMPACT

During the initial phases of geothermal development, persons in the vicinity of a geothermal site may be exposed to noise levels varying from 40 to 120 decibels, depending upon the distance from the well site. High noise levels are produced by well drilling, production testing, and well bleeding before connection to the generator. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise.

The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project (See Figure 9, Noise Characteristics at HGP-A).

Proposed county noise guidelines are 45 decibels at night and 55 decibels by day. It is expected that geothermal facilities will comply with this guideline.

Any studies [illegible] (Summer) [illegible] and [illegible]
contact with archaeologists & historians to identify sites, with
resources [illegible] and research from their card file data on [illegible] [illegible]

HISTORIC AND ARCHAEOLOGICAL VALUES

Historical values, in this context, refer to the range of historical activities carried out by early Hawaiian residents. Archaeological values refer to all structures and artifacts that provide evidence of early habitation.

The Hawaiian land use concept of the ahupuaa is most useful in understanding the range of activities likely to have occurred within a rift zone area, as well as the potential for discovery of archaeological sites. For example, early coastal fishing villages often had inland agricultural fields. In addition to fishing and farming, various forest products were harvested from mauka or upland areas (i.e., koa for canoes, pulu for stuffing, ohia logs, birds for feathers) and early trail systems connected remote villages.

Evidence of these activities found in remaining archaeological sites is critical to reconstructing Hawaiian history and pre-history.

Geothermal development runs the risk of destroying such remaining evidence by site clearing and facility construction.

Estimates of likely impacts can be accomplished by (1) plotting the location of known archaeological sites within and nearby proposed subzones, (2) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, and (3) by archaeological reconnaissance surveys on site.

The Department of Land and Natural Resources, Division of State Parks, Outdoor Recreation and Historic Sites, under its Historic and Archaeological Program, maintains records of all known historical and archaeological sites in the State of Hawaii. A survey of available information was made to determine the type, extent and significance of sites within or nearby the proposed geothermal resource subzones.

Subzone boundaries were drawn on copies of Historic Sites maps showing known sites and their identification numbers. The most recent updated mapping, done under the Coastal Zone Management (CZM) program, was used, and where updated mapping was not available, other available maps prepared by DLNR, Historic Sites section were utilized.

Each site located within a proposed geothermal resource subzone or nearby its boundaries was identified and a review of Historic Sites section records made. This information has been summarized in Appendix D including State and National Register status.

A literature search was prepared for the Kahauale'a EIS (Appendix C). Similar searches accompanied by maps showing known sites would be prepared and on-site reconnaissance surveys performed, once geothermal development sites have been selected.

[illegible] [illegible] from [illegible] EIS — [illegible]

SCENIC AND AESTHETIC VALUES

[illegible]

Scenic and aesthetic values, in general, refer to landscape qualities likely to be impacted by geothermal development. Since most geothermal resource rift zones are located in remote wilderness areas, some of which are heavily forested, development of geothermal facilities can represent a visual intrusion.

Potential sources of visual intrusion include:

- o Clearing forested areas for construction of facilities
- o Temporary 2-3 month presence of drilling rigs
- o Night lighting of drilling rigs
- o Continued drilling for new wells, replacement wells, and injection wells (continued presence of drilling rig)
- o Permanent presence of power plant structures with cooling towers (50 to 65 feet in height)
- o Geothermal fluid transmission lines
- o Electric transmission lines (70 + feet in height)
- o Periodic presence of steam plumes above well heads and power plant cooling towers (under certain climatic conditions, steam plume may rise to 150 to 200 feet above the site)

Estimates of visual impact are accomplished by preparing an area wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen. A terrain analysis of visual impacts was completed for the preparation of the Kahauale'a Environmental Impact Statement (Kahauale'a Revised EIS, June 1982) and is provided here as Appendix D, for reference.

In preparing a terrain analysis of visual impacts, various observer location points are selected and view lines calculated at each site. The observer is assumed to have an eye level 10 feet above ground surface and power plant height is assumed to be 80 feet above ground level (alternate height considered is 65 feet). Profiles or visual perspectives are constructed to show the view lines from each observer location to a proposed power plant location. From such a profile, it is possible to determine the extent to which a site is visible from each observer location.

A similar terrain analysis should be included in environmental impact assessments for the development of specific sites within a geothermal resource subzones.

RECREATIONAL VALUES

Recreational values in remote areas, include hiking, hunting, fishing, and camping. These activities are usually not limited to specific areas and can therefore occur anywhere in a rift zone.

However, there are existing, well used hiking trails in many areas; some have names and are segments of longer trail systems. In some areas, pre-historic and historic Hawaiian trail systems remain. Often, local hikers and hunters develop trails by usage.

Public hunting areas referred to as game management areas are defined in Department of Land and Natural Resources rules and mapped for public convenience on handout sheets. Conditions for use of public hunting areas is specified in the rules; however, game may also be hunted on private land at any time with a valid hunting license and permission from the landowner.

The impact of geothermal development to remote area recreation uses such as hiking and hunting may result in the loss of segments of some trails and could affect the number of game animals present in the vicinity of the geothermal development.

STATE LAND USE DISTRICTS, COUNTY GENERAL PLANS AND EXISTING LAND USES

STATE LAND USE DISTRICTS

The State Land Use Commission has placed all lands within the State of Hawaii in four major land use districts: urban, rural, agricultural and conservation.

The standards for determining the boundaries of each land use district are set forth in Chapter 205, HRS, and are as follows:

Urban Districts include those lands that are now in urban use and activities or uses as provided by ordinances or regulations of the county within which the urban district is situated.

Rural Districts include activities or uses as characterized by low density residential lots of not more than one dwelling house per one-half acre and where small farms are intermixed with the low density residential lots.

Agricultural Districts include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters, mills, storage facilities, processing facilities; and roadside stands for the sale of products grown on the premises; agricultural parts and open area recreational facilities.

Conservation Districts include areas necessary for protecting watershed and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding communities, or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

The State Land Use Districts found in each of the potential geothermal resource rift zones are:

Kilauea East Rift Zone - Conservation, agricultural, and urban districts.

Kilauea Southwest Rift Zone - Conservation, agricultural, and urban districts.

Mauna Loa Southwest Rift Zone - Conservation and agricultural districts.

Mauna Loa Northeast Rift Zone - Conservation and agricultural districts.

Hualalai Northwest Rift Zone - Conservation and agricultural districts.

Haleakala Southwest Rift Zone - Conservation and agricultural districts.

Haleakala East Rift Zone - Conservation, agricultural, urban, and rural districts.

CONSERVATION DISTRICT AND SUBZONES

Of the four land use districts, the Conservation District is the only one administered by the State of Hawaii. Individual counties administer urban, rural and agricultural lands.

Chapter 183-41, HRS, established Conservation Districts and enabled the State Department of Land and Natural Resources to promulgate regulations to implement the statute. Implementation was accomplished under the Department's Administrative Rule, Title 13, Chapter 2. Under this rule, the Conservation District is further subdivided into five subzones: Protective (P), Limited (L), Resource (R), General (G) and Special Subzones (SS).

The Protective Subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. The Limited Subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the Resource Subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General Subzones are open space areas where specific conservation uses may not be defined, but where urban use would be premature. Special Subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area. At the present time there are four Special Subzones all located on the island of Oahu.

In accordance with the Administrative Rules of the Department of Land and Natural Resources, State of Hawaii §13-2-11, 12, 13, and 14 certain uses are permitted within each of the Conservation District subzones. The following uses are permitted in the Protective Subzones:

(1) Research, recreational, and educational use which require no physical facilites;

(2) Establishment and operation of marine, plant, and wildlife, sanctuaries and refuges, wilderness and scenic areas, including habitat improvements;

(3) Restoration or operation of significant historic and archaeological sites listed on the national or state register;

(4) Maintenance and protection of desired vegetation, including removal of dead, deteriorated and noxious plants;

(5) Programs for control or animal, plant, and marine population, to include fishing and hunting;

(6) Monitoring, observing, and measuring natural resources;

(7) Occasional use; and

(8) Governmental use not enumerated herein where public benefit outweighs any impact on the conservation district.

The following uses are permited in the Limited Subzone:

(1) All permitted uses stated in the (P) subzone;

(2) Emergency warning systems or emergency telephone systems;

(3) Flood, erosion, or siltation control projects; and

(4) Growing and harvesting of forest products.

The following uses are permitted in the Resources Subzone:

(1) All permitted uses stated in the (P) and (L) subzone;

(2) Aquaculture;

(3) Artificial reefs; and

(4) Commercial fishing operations.

The following uses are permitted in the General Subzone:

(1) All permitted uses as stated in the (P), (R), and (L) subzones; and

(2) Development of water collection, pumping, storage, control, and transmission.

COUNTY GENERAL PLANS AND LAND USE POLICIES

The Agricultural, Urban and Rural Land Use Districts are administered by the individual counties. Counties administer land uses through their General Plan and/or Community Plans.

The County General Plan sets forth the broad objectives and policies for the long-range development of the County. Community Plans provide more detailed schemes for implementing the General Plan.

Hawaii County

The County of Hawaii General Plan, adopted December 15, 1971, sets forth the following goals and policies for Land Use.

Goals:

1. Designate and allocate land uses in appropriate proportions and in keeping with the social, cultural, and physical environments of the County.
2. Protect and encourage the intensive utilization of the County's limited prime agricultural lands.
3. Protect and preserve forest, water, natural and scientific reserves and open areas.

Policies:

1. Zone urban-type uses in areas with ease of access to community services and employment centers and with adequate public utilities and facilities.
2. Promote and encourage the rehabilitation and utilization of urban areas which are serviced by basic community facilities and utilities.
3. Allocate appropriate requested zoning in accordance with the existing or projected needs of neighborhood, community, region and County.
4. Establish a "land zoning bank" from which land use zoning may be allocated to specified urban centers and districts.
5. Conduct a review and re-evaluation of the tax structure to assure compatibility with land use goals and policies.
6. Incorporate innovations such as the "zone of mix" into the Zoning Ordinance in order to achieve a housing mix and to permit the more efficient development of lands which have topographic and/or drainage problems.

7. Incorporate the concept of a "floating zone" for future industrial and retreat resort areas. This concept would allow flexibility in locating future needed developments in districts which cannot be pinpointed at this time, especially in the more rural and/or remote areas.

Land uses are categorized as follows in the plan:

Urban Centers:

High Density: Commercial, multiple residential and related services (general and office commercial; multiple residential--87 to 43.6 units per acre).

Medium Density: Village and neighborhood commercial and residential and related functions (3-story commercial; multiple residential--35 to 11.6 units per acre; single-family residential--5.8 units per acre).

Low Density: Residential and ancillary community and public uses (single-family residential--no more than 4 units per acre).

Industrial Area: Manufacturing and processing; wholesaling; large storage and transportation facilities; power plants; and government baseyards.

Resort Area: Hotels and supporting services.

Agriculture Area:

Intensive: Sugar; orchard; diversified agriculture; and floriculture.

High: Fertile soil.

Low: Less fertile soil.

Extensive: Pasturage and range lands.

Orchard: Those agricultural lands which though rocky in character and content support productive macadamia nuts, papaya, citrus and other similar agricultural products.

Public Lands: Federal, State, University and County-owned lands.

Open:

Parks and historic sites.

Conservation Area: Forest and water reserves; natural and scientific preserves; open; etc.

The five potential geothermal resource areas on Hawaii contain the following county designated land use categories:

Kilauea East Rift Zone - This area is comprised of conservation, low density, medium density, resort, open area, orchards, alternate urban expansion, and extensive agriculture zones.

Kilauea Southwest Rift Zone - This area is comprised of conservation, extensive agriculture, intensive agriculture, low density, medium density, open area, and orchard zones.

Mauna Loa Southwest Rift Zone - This area is comprised of conservation, orchards, intensive agriculture, and extensive agriculture zones.

Mauna Loa Northeast Rift Zone - This area is comprised of conservation and extensive agriculture zones.

Hualalai Northwest Rift Zone - This area is comprised of conservation, extensive agriculture, and orchard zones.

Maui County

The land use objectives and policies of the Maui County General Plan December 28, 1977 are as follows for Land Use.

Objectives:

1. Uses of land meeting the social and economic needs of the people.
2. Availability of agriculture lands that are well-suited and feasible for agricultural products.
3. A lifestyle pattern based on consistent and harmonious use of land.

Policies:

1. Discourage the unwarranted conversion of agriculture lands to non-agricultural uses.
2. Minimize the encroachment of urban uses on agriculture lands.

3. Provide for compatible alternative uses on non-productive agriculture lands.
4. Enhance agricultural land use activities by providing public incentives and encouraging private initiative.
5. Develop land use guidelines reflecting the individual character of the communities and regions of the County of Maui.
6. Guide land use development patterns in sympathy with an area's natural topographic features, environmental hazard constraints, scenic amenities and other natural resource potentials.
7. Maintain the opportunity to pursue a rural lifestyle.
8. Encourage land use methods that provide a choice of housing types and locations.
9. Continue programs to identify and preserve unique and significant historic sites and natural areas.
10. Provide a wide-range of compatible land uses based on individual, community, regional and county needs.
11. Ensure the effective protection and prudent use of Maui County's coastal areas.
12. Encourage the "most reasonable and beneficial use" of land by discouraging practices that promote "the highest and best use" concept of land use.
13. Establish guidelines and programs to further reduce land speculation.,
14. Guide and integrate the development of public facilities and infrastructures with established County land use policies.
15. Encourage the Hawaiian Homes Commission to establish additional homestead lands throughout the County of Maui.

The land use categories were obtained from various community plans covering the two potential resource areas of Maui. These community plans are mandated by the Charter of Maui County (1977) and the Maui County General Plan which was adopted on June 24, 1980 as Ordinance No. 1052.

Conservation:

This use is to protect and preserve wilderness areas, open spaces, beach reserves, scenic areas, historic sites, open ranges, watersheds, and water supplies; to conserve fish and wildlife; and to promote forestry and grazing. It is intended that all lands designated as Conservation be governed by the requirements and procedures of Chapter 205, HRS, as amended, and administered by the State Department of Land and Natural Resources.

Rural:

This use is to protect and preserve areas consisting of small farms intermixed with low-density, single-family residential lots. It is intended that, at minimum, the requirements of Chapter 205, HRS, as amended shall govern this area.

Agriculture:

This use is to provide areas for agricultural development which would be in keeping with the economic base of the County and the requirements and procedures of Chapter 205, HRS, as amended. It is also expected that the County will impose more stringent requirements on these areas to ensure their use for agriculture.

Reserve:

This is primarily for areas within the State Urban District which have low priority for urban development because of environmental concerns, such as natural hazard and resource areas, archaeological sites, and other considerations, or the costs entailed with development because of the lack of nearby or adequate public facilities and services.

Single-Family Residential:

This includes single-family detached and duplex dwellings.

Multi-Family Residential:

This includes apartment and condominium buildings that have more than two dwellings.

Business/Commercial:

This includes retail stores, offices, entertainment enterprises and their accessory uses.

Light-Industrial Use:

This is for warehousing and service and craft-type industrial operations.

Heavy-Industrial Use:

This is for major industrial operations whose effects are potentially noxious due to noise, airborne emissions or liquid discharges.

Hotel/Resort:

This applies to transient accommodations which do not contain kitchens within individual living units but may include a restaurant or small shops serving hotel guests.

Public/Quasi Public:

This includes schools, libraries, fire/police stations, government office buildings, public utilities, hospitals, churches, cemeteries, and community centers.

Airport:

This includes all commercial and general aviation airports.

Park:

This includes all public active and passive parks.

The two potential resource areas on Maui contain the following land uses:

Haleakala Southwest Rift Zone - This area is comprised of conservation, agriculture and park zones. The park area is located southwest of Kihei Road at Cape Kinau.

Haleakala East Rift Zone - This area is comprised of conservation, agriculture, rural, reserve, single-family residential, multi-family residential, business/commercial, light-industrial use, hotel/resort, public/quasi public, and park zones.

EXISTING LAND USES

Existing land uses in potential geothermal resource areas are characteristic of their respective zoning. Most potential areas are zoned conservation and may include forest reserve, national and state parks, other forested areas, brush and grass lands, and barren lava flows. Often conservation zoned lands provide habitat for native and rare or endangered species as well as hunting area, and watershed lands.

Potential resource areas zoned agricultural are used mostly for livestock grazing.

The only urban zoned areas are those located at Pahoa and Kapoho in the Kilauea East Rift Zone, Hawaii; and Hana, in the Haleakala East Rift Zone, Maui. The only Rural zoned area is located at Pahoa, Hawaii.

Table 7 summarizes existing land uses in each resource area.

COMPATIBILITY OF GEOTHERMAL RESOURCE DEVELOPMENT WITH SURROUNDING LAND USES, AND ZONING

Act 296 in addressing the designation of geothermal resource subzones requires assessement of each geothermal resource area by an examination of various factors including the compatibility of geothermal development and potential related industries with existing land uses and those uses permitted under Section 205-2, Hawaii Revised

Table 7. Land Use in Geothermal Areas

Description	Kilauea			Mauna Loa		Hualalai	Haleakala	
	NE Rift Lower	NE Rift Upper	SW Rift Kau	E Rift	SW Rift	NE Rift	NE Rift Hana	SW Rift
URBAN:								
Residential	●						●	
Commercial	●						●	
RURAL:								
Residential	●							
AGRICULTURE:								
Cropland	●	●						
Grazing	●	●	●	●	●	●	●	●
Residential	●	●			●			●
CONSERVATION:								
Forest Reserve	●	●					●	●
National Park		●	●					
State Park	●							
Other Forests	●	●	●	●		●	●	●
Brush & Grassland	●	●	●	●	●	●	●	●
Lava Flows (barren)	●	●	●	●	●			●
Endangered Mammal				●	●			
Endangered Bird				●	●	●		●
Wildlife Sanctuary				●	●			
Hunting Area	●	●		●	●			
Watershed							●	●

Statutes, relating to State Land Use Districts, Section 183-41, HRS, relating to Conservation Districts and all uses permitted under County general plans or land use policies.

Act 296 allows geothermal resource subzones to be designated within any of the four state land use districts--urban, rural, agricultural and conservation. As such, once subzones are established, geothermal facilities could be located adjacent to any land use existing or permitted in any of the four districts.

Compatibility simply means being capable of living or performing in harmonious combination with each other. Some land uses are obviously more compatible than others depending on their characteristics.

As noted in the Flora and Fauna Section of this report, forested areas may be categorized by the amount of canopy and quantity of native forest present, the assumption being that undisturbed closed canopy native forest would be the most susceptible to disruption by geothermal development. Thus, geothermal development would be least compatible with a Category 1 forest consisting of exceptional native forest with a closed canopy and over 90% native cover. Category 2 forest consists of mature native forest with over 75% native canopy. Category 2A consists of native scrub and low forest and Category 3 consists of cleared land, non-native forest, or bare ground or lava. Category 3 forest is considered more compatible with geothermal development than Category 1 forest. However, construction of a geothermal power plant in Category 2A native scrub and low forest or in Category 3 open, cleared land or barren-lava flows result in visual intrusions which might be otherwise hidden in a Category 1 or 2 forest.

Conservation districts constitute a large percentage of the potential resource areas. Each area within the conservation district has permitted uses. In each of the subzones mentioned, Protective, Limited, Resource and General; the use of the area for "monitoring, observing, and measuring natural resources" is permitted. In this respect exploration of geothermal resources can be allowed in a conservation district. The development of these resources can then eventually lead to widespread public benefit. The use of lands within a conservation district in which "governmental use not enumerated herein where public benefit outweights any impact on the conservation district" is permitted. In managing the uses of conservation lands, careful analysis of the proposed use is required. Thus, only when the benefits of the proposed use are determined to be greater than any impact on the land, will the use be permitted.

In addressing land use compatibility, several assumptions must be made.

- o Ambient air quality will not be effected since it is expected that current abatement technology will be fully utilized in compliance with proposed State Department of Health air quality standards for geothermal development.
- o Proposed County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with. It is also assumed that the County of Maui will adopt similar noise guidelines in reference to geothermal activities.
- o Geothermal facility siting will be adjusted to avoid endangered plants and significant archaeological or historical sites.
- o Visual impacts will be minimized by adjusting the location of the site, the alignment of structures so as to present the smallest possible aspect and by blending structures with surroundings by painting appropriately and by use of non-reflective, light absorbent materials and textures and by shielding facilities from view by locating behind a puu, or hill, or by placement in a forested area.
- o Impacts will be further minimized by use of buffer zones surrounding geothermal facilities.

EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

Evaluation of impacts on potential geothermal resource areas was accomplished by reviewing available information for each geothermal resource area. Information on meteorology, surface water, ground water, underground injection control areas, existing land uses, flora and fauna and historic and archaeological sites was developed by mapping on a series of overlays for each geothermal resource area. The following evaluation is the product of the overlay mapping and data review process.

KILAUEA EAST RIFT ZONE

Under trade wind conditions, during the day, northeast trade winds pass through the entire rift zone. Wind speeds vary from light to fast depending on the topography. The southern half of the rift zone will have moderate to fast trade winds, while the northern half will have light to moderate wind speeds. At night, the moderate northeast trades pass through the eastern end of the zone while gentle to moderate northerly drainage downslope winds pass through the remainder of the rift zone.

Under non-trade wind conditions, during the day, gentle to moderate sea breeze-upslope winds from the southeast through southwest pass through the rift zone. At night, gentle to moderate downslope winds from the higher slopes drain down through the rift zone from the north through west.

Rainfall is heavy over most of the central northeast half of the rift zone--over 100 inches a year. Rainfall falls off sharply at the western end of the rift zone from 100 inches a year to 35 inches a year in a short distance of less than 2 miles. The western end of the rift zone has the lowest rainfall.

Hawaii Volcano National Park Headquarters at 3,970 feet elevation, Pahoa at an elevation of 650 feet, and Pohoiki at an elevation 10 feet can be used as representative temperature stations in the rift zone. Pahoa and Pohoiki have average annual maximum and minimum temperatures of 78.2°F and 63.4°F, and 81.2°F and 67.2°F, respectively. The average annual temperature at National Park Headquarters is 68.1°F and 52.9°F.

There are no known surface streams or natural water storage features in the Kilauea East Rift Zone, with the exception of Green Lake in Kapoho Crater.

Ground water occurs as dike water and basal water in the Kilauea East Rift Zone. The only known perched water exists north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic gradients along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone on ground water movement. The effectiveness of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels.

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 19,000 mg/l. Because of the effects of mixing, most ground water at the coast is brackish. Salinity and temperature vary greatly north and south of the rift zone. Wells and shafts north of the rift zone are characterized by lower temperatures and lower salinities. Wells in and near Keaau have water temperatures of 66° to 68°F. The water temperature of wells near Pahoa ranges between 72° and 74°F. Wells located more than 3 miles inland generally have a chloride concentration of less than 20 mg/l. South of the rift zone, high well-water temperatures and salinities are encountered. The water temperature of the Malama-Ki well, No. 2783-01, in 1962 was 127-130°F with salinity between 5500 and 7000 mg/l at pumping rates of 100 to 480 gpm. The water temperature of thermal test well No. 3 in 1974 was 199°F, with salinity of 2000 mg/l. The average chloride content of ground water south of the rift zone is probably greater than 3000 mg/l, probably due in part to heating of sea water by volcanic activity below the basal lens. The warmer, less dense sea water rises, contaminating the fresh water in the basal aquifer.

LOWER KILAUEA EAST RIFT ZONE

Property in the lower portion of the Kilauea East Rift Zone is owned by six large area landowners and numerous small area landowners. Large area landowners include the State of Hawaii, Bishop Estate, Campbell Estate, Puna Sugar Company, Kapoho Land Development Corporation, and Tokyu Land Development Corporation.

Property within the Lower East Rift Zone is zoned Agricultural, Conservation, Urban and Rural. It should be noted that existing land uses in Agricultural zoned areas include both cultivated and uncultivated land, and agricultural subdivisions. Agricultural subdivisions are designated by the County of Hawaii as A-1a, meaning an agricultural subdivision of one acre lots. Five one-acre subdivisions are located within the rift zone boundaries, and include Leilani Estates, and Nanawale Subdivision. Conservation zoned areas include Forest Reserve lands, the Wao Kele O Puna Natural Area Reserve and the Kapoho Lava flow of 1960. Urban areas within the rift zone boundaries include Pahoa, Kaniahiku Village and a small portion of the Kapoho Beach Lots.

Lava flows in the Lower East Rift Zone include flows dated 1750, 1790, 1840, 1845, 1955, 1960, 1961, and 1983.

Forested areas in the Lower East Rift Zone consist primarily of Category 2 and 2A forest, mature native forest with over 75% native cover and native scrub and low forest. Isolated areas of Category 1 exceptional native forest with over 90% mature cover and closed canopies do exist in the Keauohana Forest Reserve, consisting of ohi'a-lama forest, in the vacinity of Puu Kaliu and at higher elevations in the Wao Kele O Puna National Area Reserve. Category 3, bare lava, cleared land is more evident in coastal area, especially in the Kapoho area, at Cape Kamukahi.

There is no endangered species essential habitat in the Puna area, since large portions of the area are either cleared agricultural land or bare lava.

Five historic sites are located in the Lower East Rift Zone:

Site No. 7388 - Pahoa District, town.

Site No. 4295 - Pualaa Complex, including an ancient holua slide.

Site No. 2501 - Kapoho Petroglyphs, considered unique, and placed on the State Register of Historic Sites.

Site No. 7492 - Lyman Historic Marker

Site No. 2500 - Kukii Heiau, reamins of heiau built by Umi on his tour of Hawaii after coming to power.

Development of geothermal resources in the Lower East Rift-Zone has been underway since 1973-74 with the issuing of geothermal resource mining leases for four areas, designated GRML R-1, R-2, R-3, and R-4. Development of additional sites in the Lower East Rift zone will not impact any endangered species essential habitat, but may impact existing communities in terms of noise and aesthetics. The provision of a buffer zone will help to mitigate such impacts. Air Quality will not be impacted, since it is expected that given current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

UPPER KILAUEA EAST RIFT ZONE

Property in the Upper East Rift Zone is owned by four large area landowners, the United States of America (Hawaii Volcanoes National

Park), the State of Hawaii, Bishop Estate, and Campbell Estate. Smaller holdings owned by various individuals are found in the Royal Gardens Subdivision along the coast and in urban and agricultural zoned areas in the Kilauea-Olaa area at the mauka boundary of the rift zone.

The Upper East Rift Zone is primarily zoned Conservation, Protective, Resource and Limited Subzones. Exceptions are the Ainahou Ranch land, Royal Gardens Subdivision, zoned for agricultural use, and the urban and agricultural zoned areas in the Kilauea-Olaa area.

Existing land uses include the Hawaii Volcanoes National Park (the largest area), forested areas in Kahauale'a, a grazed area in the vicinity of Ainahou Ranch, a portion of the Wao Kele O Puna Natural Area Reserve, and the Volcano and Royal Gardens Subdivisions. Also included are portions of the Kilauea Forest Reserve, Kilauea Military Camp, and Kilauea Golf Course.

Included on the list of existing land uses is the Campbell Estate/True Mid-Pacific Geothermal Development area as approved for exploration by the Board of Land and Natural Resources in 1983.

Forested areas in the upper portion of the East Rift Zone consist primarily of Category 1, exceptional native forest with over 90% native cover and closed canopy, and Category 2 mature native forest with over 75% native cover interspersed with bare lava flows, dated 1968-1973, 1977 and 1983-84.

Essential endangered species habitat for 'o'u encompasses a major portion of the Kahauale'a area, and extends into the Hawaii Volcanoes National Park land to the south. The Dark-rumped Petrel is known to nest in Napau Crater and I'o have established territory at Makapuhi Crater and at lower elevations in the vacinity of the Royal Gardens Subdivision.

There are no known archaeological sites within the Upper East Rift zone.

Development of geothermal resources in the Kilauea Upper East Rift zone will be limited to areas outside the Hawaii Volcanoes National Park. Air quality within surrounding areas will not be impacted since it is expected that, given the current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

Site development may impact endangered o'u habitat; however, as stated in the Kahau'alea Environment Impact Statement (June 1982), "the minimal removal of vegetation and trees within the Kahau'alea project area should not significantly threaten the O'u." (pg. 5-11).

It should also be noted that a portion of the O'u habitat has been lost due to recent lava flows.

KILAUEA SOUTHWEST RIFT ZONE

Under trade wind conditions, during the day, moderate to moderately strong northeast trade winds are expected to sweep through the rift zone. At night moderate drainage winds from the upper slopes of Mauna Loa should sweep through the rift zone from the north.

Under non-trade wind condition, during the day, light to moderate southerly sea breeze-upslope winds are expected to pass through the rift zone. At night, the light to moderate drainage winds from the north are expected to pass through the rift zone.

There is great variation in the amount of rainfall over this rift zone--from about 100 inches a year at the northern end of the rift zone near Hawaii Volcano National Park Headquarters to about 20 inches a year at the southern end of the rift zone near Hilina Pali in the Kau Dessert. The greatest variation in rainfall is at the upper end of the zone where in the short distance of about a mile from the National Park Headquarters to Halemaumau, the rainfall drops from 100 inches a year to 50 inches a year. There are no rainfall stations in the Kau Dessert.

Hawaii Volcano National Park Headquarters, at 3,970 feet elevation, with an average maximum and minimum temperature of 68.1°F and 52.°F, respectively, is the only temperature station in the rift zone.

There are few streams in the Kilauea Southwest Rift Zone because the water quickly percolates into the young and highly permeable lava flows. A few well-defined stream channels are found between Waiahaka Gulch, near Kapapala Ranch, and Hilea Gulch. No stream has continous flow into the sea, and flood flows reach the sea infrequently and only for short periods.

Ground water in the coastal areas of the rift zone is brackish; at higher elevations dike confined water is present. The Underground Injection Control line is set at an elevation of 200 feet in most of the coastal area but drops to an elevation of 100 feet within the rift zone near Waiapele Bay. Lava flows within the rift zone are dated 1823, 1868, 1920, 1971 and 1974.

Property within the Kilauea Southwest Rift Zone is owned by the State of Hawaii, United States of Amercia (Hawaii Volcano National Park), Bishop Estate, Ka'u Sugar, International Air Service, Seamountain Hawaii, C. Brewer, and a number of small parcel landowners.

Rift zone areas are zoned either Conservation, Resource and Limited Subzones, or Agricultural. All rift zone areas, except for National Park lands, are presently used for grazing.

The nearest urban or residential areas are Pahala, north of the rift zone, and Punaluu, west of the rift zone. Both communities essentially border the rift zone area.

This area is poorly characterized biologically. It was not included in USFWS vegetation mapping. The area is generally disturbed, with some pockets of native scrub along the coast and near the boundary of the national park, and is of little biological significance since it contains no endangered species habitat.

There are no known archaeological sites within this subzone.

Development of geothermal resources in portions of this rift zone, outside the National Park, would probably result in minimal environmental impact.

Development proximity to the Pahala and Punaluu communities may result in aesthestic impact. Air Quality will not be impacted since it is expected, given the current technology level that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal development.

MAUNA LOA NORTHEAST RIFT ZONE (KULANI)

Tradewinds during the day diverge around Mauna Loa and pass through the rift zone from the east to southeast. At night, reverse flow results from drainage of mountain breeze-downslope winds. Under non-trade conditions, light to moderate sea breeze-upslope winds flow through the rift zone from southeast to east. At night, mountain breeze downslope winds flow from the west.

Rainfall is heavy--150 inches a year at the 3,500-foot elevation to 60 inches a year at the 7000 foot elevation. Kulani Camp receives 102 inches a year (elevation 5,170 feet). Temperature at Kulani Camp ranges from an average annual maximum of 63.5°F up an average annual minimum of 46.5°F.

There are no known surface streams in this subzone area. Dikes occur above the 5400-foot elevation. The subzone area ranges in elevation from 3600 feet to 7000 feet.

Property within the proposed subzone is owned by Bishop Estate and the State of Hawaii, and is zoned Agricultural and Conservation. The nearest residential area is Kaumana on the north, approximately 6 miles from the subzone boundary. Volcano House in the National Park is approximately 8 miles from the southern subzone boundary.

Existing land uses within the proposed subzone boundary include the Agricultural zoned grazing land belonging to Bishop Estate and the State's Kulani Honor Camp, located in the Conservation District, Resource Subzone. The remaining lands within the subzone are forested and includes portions of the Mauna Loa, Kilauea, and Upper Waiakea Forest Reserves and two game management areas on the northwest and southwest corners of the subzone. Puu Makaala Natural Area Reserve is included in the southeast corner of the subzone.

Forested areas consist of Category 1, exceptional native forest; closed canopy with over 90% native cover. The remaining forest areas, consist of Category 2, mature native forest with over 75% native canopy. Forested areas in the upper and northern portion of the proposed subzone are dissected by recent lava flows dated 1852, 1942, and 1984.

Category 1 forests include tall Metrosideros polymorpha (Ohia lehua), and Acacia koa (koa) with native shrubs and tree ferns (Cibotium spp. hapuu). Category 2 includes moderate to tall Ohia lehua and koa, with native shrubs and ferns. Category 2A includes scattered Ohia lehua and Mamane, in some areas.

Mauna Loa forests within the subzone area provide habitat for four endangered forest bird species; the Hawaii Creeper, Akepa, Akiapola'au and the 'O'u, and the Nene. The Mauna Loa East Rift forests have been designated as essential habitat for the four endangered forest birds. In addition, 'Io, the Hawaiian Hawk, is known to nest at two sites, one on the lower slopes of Kulani Cone and a second site directly due West at an elevation of 5500 feet.

It should be noted that the designated essential habitat area includes the grazed agricultural zoned areas belonging to Bishop Estate since these areas contain both Category 1 and 2 forests as well as open areas. There are no known archaeological sites within the subzone area.

Development of a geothermal resource in areas other than the cleared grazed agricultural land may impact the four endangered forest bird species and the Nene by disturbing essential habitat areas.

MAUNA LOA SOUTHWEST RIFT ZONE (KAHUKU RANCH)

There are no wind data in this rift zone. Under trade wind condition, during the day, the lower half of the rift zone is expected to have light to moderate easterly trades passing through the rift zone. The northern upper half of the rift zone will likely have light to moderate upslope winds from the south. During the night, light to moderate northerly mountain breeze-downslope winds are expected to flow through the rift zone.

Under non-trade wind conditions, during the day, light to moderate southerly upslope winds are expected to pass through the rift zone. During the night, gentle to moderate drainage winds from the higher slopes are expected to pass through the rift zone from the north. Precipitation ranges from 40 to 50 inches decreasing at the upper elevations to 40 inches.

No surface streams are found within the subzone area. Dikes are found in the upper elevations of the subzone area; basal ground water is fresh, and the UIC line lies to the south outside the subzone area. There are no existing wells within the subzone area.

The subzone area is almost wholly owned by the S.M. Damon Estate, except for a small portion on the eastern subzone boundary which is state-owned.

Existing land uses within the potential subzone area include grazing land, a portion of the sparsely settled Hawaiian Ocean View Estates, and forest lands. The subzone boundary extends makai of Highway 11, to the Kahuku Ranch area. The nearest population centers are to the east, Waiohinu and Naalehu towns, and Kiolakaa-Keaa Homestead area. The subzone area is zoned agricultural and conservation.

Forested areas consisting mostly of mature native forest, with over 75% native cover, are interspersed with areas of bare lava from flows dated 1886, 1887, 1907, 1916, and 1926.

Above the 5000-foot elevation, forested and bare lava areas provide habitat for the Nene and two species of endangered forest birds, Hawaiian Creeper and Akiapolaau. On the eastern boundary between the 3000-foot and 3600-foot elevations, three species of endangered forest birds (Akepa, Akiapolaau and Hawaiian Creeper) occupy an area designated as exceptional native forest, with a closed canopy and over 90% native forest cover. The subzone area lies to the east of the Manuka Natural Area Reserve; no portion of the reserve is included in the proposed subzone.

Historic sites are found only at the subzone perimeter at Kahuku Ranch. No significant archaeological or historic sites were recorded within the subzone boundaries.

Development of geothermal resources in the lower, agricultural-zoned portion of the proposed subzone may result in minimal environmental impact provided a buffer area is maintained between the geothermal development site and the Hawaiian Ocean View Estates.

HUALALAI NORTHWEST RIFT ZONE

Although no wind instrumentation exists on Hualalai, knowledge of other upland areas indicated that light to moderate upslope sea breezes converge on Hualalai during the day; at night, the reverse gentle to moderate downslope mountain breezes diverge in all directions from the Hualalai Summit. Rainfall varies from light to moderate, from 30 to 40 inches a year.

There are no known surface streams in this area; however south of the subzone area, man-made catchments and collecting ponds are used to provide water for ranch purposes. Dikes occur in this subzone and elevations range from 3400 feet to 7200 feet.

Property within the subzone is wholly owned by Bishop Estate and zoned Conservation except for a triangular section on the southeast slope, and two small segments along the northwest perimeter that are zoned agricultural. The nearest residential areas occur along the Mamalahoa Highway to the west; Kailua-Kona is located seven miles southwest of the subzone. Except for the triangular shaped agricultural land, which is grazed, all other land within the subzone is forested. Approximately one-half of the forested area lies within the Kaupulehu Forest Reserve.

Forested areas consist of mature native forest, with over 75% native canopy. Exceptional native forest with over 90% native canopy is found along the subzone boundary between elevations of 4000 to 6500 feet. Species composition consists primarily of Metrosideros polymorpha (ohia lehua), Acacia koa (koa), and Sophora chrysophylla (mamane). The subzone is crossed by a single lava flow, the Kaupulehu Flow.

Hualalai slopes within the subzone area provide habitat for four endangered species. The species composition varies with elevation. Between 3200 feet and 6000 feet Alala, Hawaiian Creeper and Akepa are found; between 6000 and 7000 feet Hawaiian creeper, Akepa and Nene are found; and above the 7000-foot elevation, only Nene.

No archaeological or historical sites have been recorded within the subzone area.

Development of geothermal resource in areas other than the grazed agricultural zoned portion of the subzone may impact the endangered species known to exist within the proposed subzone area. Alala, the Hawaiian Crow, is reported to number fewer than 20 individuals. Disturbance of their Hualalai habitat may cause further decline of this species and, possibly, its extinction.

HALEAKALA SOUTHWEST RIFT ZONE

Wind data for coastal sites indicate that under tradewind conditions, during the day light to moderate sea breeze-upslope winds from the southeast and the west flow from the coast to upper elevations. At night the reverse, mountain breeze-downslope winds occur. Similar sea breeze, mountain breeze winds, occur during non-tradewind conditions.

Rainfall in the rift zone ranges from 16 inches a year in coastal areas to 54 inches a year near Polipoli Spring.

Average annual maximum and minimum temperatures at the coast in the rift zone are expected to be about 84°F and 64°F, respectively; at 3000 feet 72°F and 55°F could be expected, and at 7000 feet a maximum of 63°F and a minimum of 44°F.

There are no know surface streams in this geothermal resource area. Several springs along the mauka northern fringes of the area provided water for minor uses, including camp water for the Polipoli Mountain Park.

Ground water in the rift zone is brackish below 1600 feet level and fresh basal water above. However, the rift zone also contains dike-confined ground water.

Property within the rift zone is owned by the State of Hawaii, Ulupalakua Ranch and other individual holders of smaller parcels. The coastal portions of the rift zone and mountain areas above 5000 feet are zoned Conservation, Protective, and General Subzones, and Resource Subzone, respectively. All mid-level areas not zoned Conservation are zoned for agricultural use.

The Ahihi-Kinau Natural Area Reserve from Kanahena to Keoneoio, including near-shore submerged lands, is located in the coastal portion of the rift zone. This Natural Area Reserve contains anchialine pools, marine ecosystems and the last lava flow (dated 1790) on the Island of Maui. Upslope, Ulupalakua Ranch land is used for grazing. The upper most portion of the rift zone above 5000 feet is designated as the Kula and the Kahikinui Forest Reserves. Polipoli State Park is located along the northern rift zone boundary. The nearest urban or residential areas are Makena, one mile north of the rift zone boundary; Ulupalakua Ranch, immediately northwest of the rift-zone along the Kula/Piilani Highway; and Keokea, approximately 2 miles northwest of the upper portion of the rift zone. "Science City" and the perimeter of the Haleakala National Park are located five miles upslope of the upper boundary of the rift zone.

Vegetation in the Haleakala Southwest Rift Zone consists of native scrub vegetation and some exotic tree plantings as well as substantial areas of pastureland with occasional forested areas. The lower portions of the rift zone are barren lava with isolated pockets of Category 1, exceptional native forest with closed canopy of over 90% native cover.

There is no endangered species habitat in this rift zone, although the middle elevations contain some very valuable, although disturbed, dry native forest.

There are five known archaeological sites in or on the perimeter of the rift zone:

1. Poo Kanaka Stone (site #1021) located near the Kula Highway and has been placed on the State Register of Historic Sites;
2. Puu Naio Cave (site #1009) located on the southwest rift zone boundary at an elevation of 1100 feet; also on the State Register;
3. Kalua O Lapa Burial Cave (site #1017) located at the eastern boundary of the Ahihi-Kianu Natural Area Reserve;
4. Maonakala Village Complex (site #1018) a coastal village site, also within the Natural Area Reserve;
5. La Perouse Archaeological District located at the southern boundary of the rift zone and on the State Register.

Development of geothermal resources within the grazed agricultural zoned portions of the rift zone will result in minimal environmental impact since no endangered species habitat is present.

Makena residential and resort developments, Ulupalakua Ranch and upslope, the Haleakala "Science City" may be affected aesthetically. Air quality in urbanized areas will not be impacted since it is expected, given the current level of technology, that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal resource development.

HALEAKALA EAST RIFT ZONE

In coastal areas, during tradewind conditions, northeast tradewinds prevail during the entire day and night. Wind speeds are moderate during the day and light at night. During a non-tradewind conditions, the winds are almost calm during the night and light during the day. The direction of the wind is from the south during the night and from the west during the day, which is opposite of what would be expected under the sea breeze-upslope winds during the day and mountain breeze-downslope winds during the night.

In upper areas, northeast tradewinds continue across the rift zone during the day and the night, however mountain breeze downslope winds meet the trades somewhere mid-level in the subzone.

Under a non-tradewind condition, gentle to moderate daytime sea breezes flow upslope and night time mountain breezes move downslope.

The average annual rainfall in the upper half of the rift zone is 200 inches with a possible maximum of over 300 inches on the northern side of the zone. Rainfall decreases toward the east to 65 inches a year at the coast.

At Hana Ranch the average annual maximum temperature is 80°F, and the average anuual minimum is 67.4°F.

Extrapolated average annual maximum and minimum temperatures at upper elevations are 72.4°F/56.8°F at 2500 feet; and 58.9°F/45.4°F at 7000 feet.

Streams in the Haleakala East Rift Zone are ephermal in spite of the high rainfall. The rocks are highly permeable, allowing all but the heaviest rains to sink rapidly into the ground. Rising from sea level at Hana Bay to the 7000-foot level near the eastern rim of Haleakala Crater, the area's rugged topography contains the headwaters of the several tributaries of Kawaipapa Gulch along the resource area's northern boundary and Moomoonui Gulch along the southern boundary. The makai area contains the intermittent Holoinawawae Stream that empties into Hana Bay.

Dikes occur throughout the middle and lower portions of the rift zone. The Underground Injection Control (UIC) line is set at an elevation of 200 feet.

Property within the rift zone is owned by the Hana Ranch, (lower elevations), the State of Hawaii (mid and upper elevations) and the United States of America (upper-most elevations). Smaller parcels in coastal areas belong to other landowners.

Lower elevation Hana Ranch land is zoned for agricultural use and is grazed. State land above the Hana Forest Reserve Boundary is zoned Conservation, Protective and Resource Subzones and is also designated as a Public Hunting area where wild pig and goat can be hunted year-round.

Hana Town and its rural community are located within the proposed subzone area along the coast.

Forested areas above 3000 feet uniformly consist of Category 1 exceptional native forest, closed canopy with over 90% native cover. Below the 3000-foot level the forest is more disturbed and gradually blends into Category 2, mature native forest with over 75% native canopy. Below the 1000-foot level the forest gives way to pastureland with occasional forested areas.

Forested areas above the 5000-foot level provide habitat for three endangered forest birds, the Maui Parrot bill, the Crested Honeycreeper, and the Akepa. Akepa habitat extends to lower elevations to the 4200-foot level.

All known archaeological sites are at or below the 200- foot level. Site No. 1078, at 200 feet is a fishing shrine which is on the State Register of Historic Places. Six other sites are located at lower elevations in coastal areas in rural and urban zoned areas.

Development of a geothermal resource in the Haleakala East Rift Zone in areas other than the grazed agricultural lands below the 1000-foot level may impact native forest bird habitat and above 4200 feet, endangered forest bird habitat. However, development of a geothermal resource below the 1000-foot level in grazed agricultural land could place a well and power plant as close as 7000 feet from the center of Hana Town. Quite clearly, the rural lifestyle of the Hana Community could be affected.

REFERENCES

METEOROLOGY

Rainfall:

National Oceanic and Atmospheric Administration, Climate of Hana, HI, Climatography of the U. S. No. 20. April 1978.

State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, Median Rainfall, State of Hawaii, Circular C88, June 1982.

Temperature:

State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, Average Maximum and Minimum Temperatures.

Wind:

Harland Bartholomew and Associates Climatological Data For Wailea, Maui, prepared for The Matson Navigation Co., S.F., CA December 1960.

True/Mid-Pacific Geothermal Venture in coordination with Campbell Estate, Revised Environmental Impact Statement for the Kahauale'a Geothermal Project, 1982.

Ekern, Paul C. and Alfred J. Garrett. Project Ahupua'a, Solar Meteorological Field Measurements on the Island of Hawaii. Summer, 1978-2. Eastern Flank of Mauna Loa. UHMet 79-04 Dept. of Metoeorlogy, University of Hawaii, August 1979.

Ekern, Paul and R. Becker. Project Ahupua'a, Solar Meteorological Field Measurements on the Island of Hawaii, Summer 1978-5. Southern Flank of Mauna Loa, Dept. of Meterology, University of Hawaii, 1979.

Leopold, Luna B., The Interaction of Trade Wind and Sea Breeze, Hawaii, J. of Meteorology, Vol. 6, No. 5, October 1949.

Steven W. Lyons. Summer Weather on Haleakala, Maui, UHMet 79-09, Dept. of Meteorology, University of Hawaii, April 1979.

Mendonca, Bernard G., Local Wind Circulation on the Slopes of Mauna Loa, J. of Applied Meteorology, August 1969.

Mendonca, Bernard and Wayne Iwaoka, The Trade Wind Inversion at the Slopes of Mauna Loa, Hawaii, J. of Applied Meteorology, April 1969.

Peterson, Carl M., The Trade Wind Regime of Central and Western Maui, Tech. Memorandum No. 1, Weather Bureau, January 1966.

Schroeder, Thomas A., Project Ahupua'a, Solar Meteorolgical Field Measurements on the Island of Hawaii. Summer 1978-3. Trade Wind Interactions with Local winds in South Kohala. UHMet 79-05, Dept. of Meteorology, University of Hawaii, February 1980.

Schroeder, Thomas A., Thomas G. Tarlton, and P. Anders Daniels, Maui County Wind Power Survey, Part 2: Molokai Mobile Sampling Program 21 June to 31 July 1977, Part 3: Maui Fixed Station Data September 1976 to July 1977, UHMet 77-04, Dept. of Metoeology, University of Hawaii, October 1977.

FLORA AND FAUNA

Berger, A.J., Hawaiian Bird Life, University Press of Hawaii, Honolulu, 1972,

Carlquist, S., Hawaii: A Natural History, Natural History Press, Garden City, New York, 1970.

Carson, H.L., personal communication 5/31/84.

Corn, C., personal communication 4/27/84.

Christensen, C., personal communication 5/30/84.

Griffin, C., personal communication 5/1/84.

Jacobi, J., Mapping and Natural Vegetation of the Hawaiian Islands, XV Pacific Science Congress, Dunedin, New Zealand, 1983.

_____, personal communication 5/28/84.

Kepler, C. and M. Scott Distribution and Behavior of the Hawaiian Hoary Bat, unpublished manuscript, U.S. Fish and Wildlife Service, 1984.

Lassetter, J. Stuart and Charles R. Gunn, Vicia Menziesii Sprengel (Fabaceae) Rediscovered, Its Taxonomic Relationships, Pacific Science (1979), Vol. 33, No. 1, Honolulu.

Medeiros, A., personal communication 1984.

Scott, M., unpublished monograph, 1984.

State of Hawaii, Department of Land and Natural Resources, Division of Forestry, A Botanical Reconnaissance of Malama-Ki Forest Reserve, Honolulu, 1981.

_____, A Vegetation Survey of the Halepuaa Forest Reserve, Honolulu, 1979.

_____, Statewide Non-game and Endangered Species Program, Job Report, 1984.

Environmental Protection Agency (EPA), Pollution Control Guidance for Geothermal Energy Development; National Technical Information Service, Springfield, Virginia, 1978.

United States, Department of the Interior, Fish and Wildlife Service, Alala Recovery Plan, Denver, 1982.

_____, Hawaiian Dark Rumped Petrel and Newell's Manx Shearwater Recovery Plan, Denver, 1983.

_____, Hawaii Forest Birds Recovery Plan, Denver, 1983.

_____, Nene Recovery Plan, Denver, 1983.

AIR QUALITY

Dames and Moore, Report Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii, Honolulu, 1984.

Houck, James E., Environmental Baseline Survey Kilauea East Rift Zone, Volume 1, Final Report (Study Period December 1982 through December 1983).

_____, Progress Report, January 1, 1984 through May 31, 1984, Environmental Baseline Survey, Year Two, Kilauea East Rift, Puna and Ka'u Districts, May 31, 1984,

State of Hawaii, Department of Health, Environmental Protection and Health Services Division, Proposed Revisions to Administrative Rules, Chapter 11-60, Air Pollution Control, covering Geothermal Activities, Draft dated 3/22/84.

NOISE

Dames and Moore, Report Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii, Honolulu, 1984.

State of Hawaii, Department of Planning and Economic Development, Geothermal Energy of Hawaii, Volume II, Honolulu, 1981.

_____, Geothermal Power Development in Hawaii, Volume 1, Honolulu, 1982.

True/Mid-Pacific Geothermal Venture in Coordination with Campbell Estate, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June, 1982.

STATE LAND USE DISTRICTS: COUNTY GENERAL PLANS, AND EXISTING LAND USES

Hawaii, County of, The General Plan, County of Hawaii, Hilo, January 1971.

Maui, County of, Maui County General Plan, December 28, 1977.

State of Hawaii, Department of Land and Natural Resources, Administrative Rules, Title 13, Chapter 2, and Subzone Maps.

_____, Board of Finding of Fact, Conclusions of Law and Decision and Order, in the Matter of the Conservation District Use Application of the Estate of James Campbell, CDUA No. HA-3/2/82-1463, Honolulu, February 25, 1983.

State of Hawaii, Land Use Commission, District Boundary Maps.

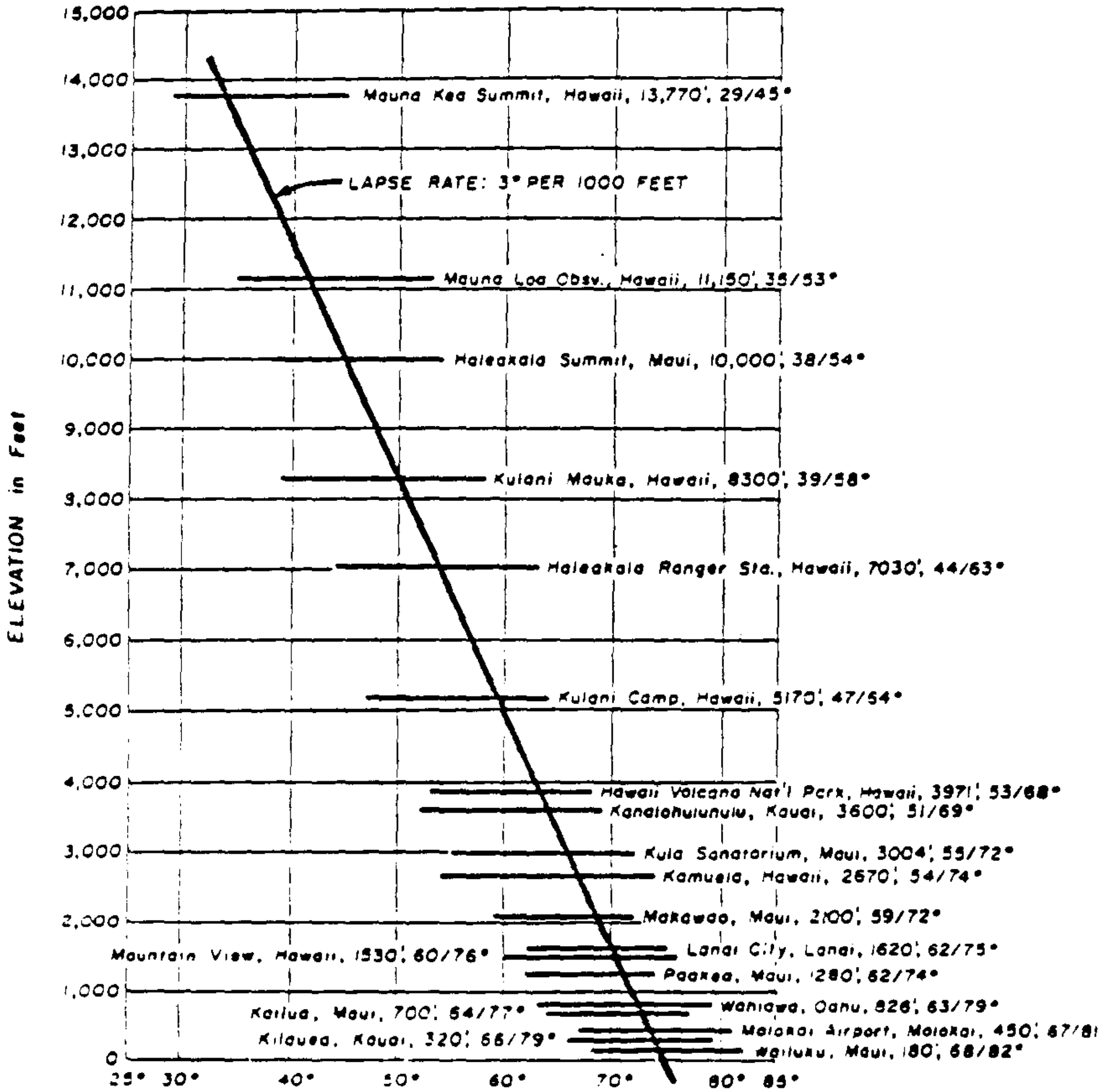

Figure 1. Decrease in Temperature at Various Elevations, Various Locations in the State of Hawaii.

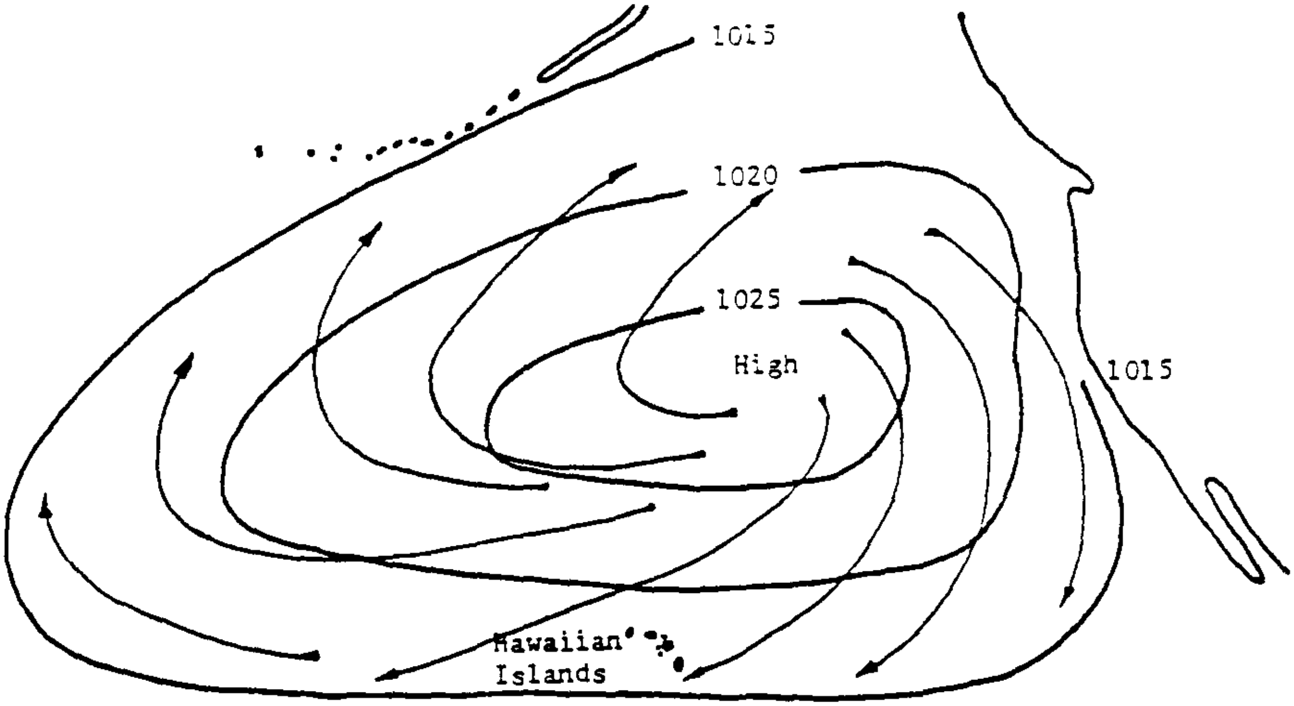

Figure 2a. Mean Pressure (millibars) and Wind Flow in the Eastern and Central North Pacific for July (summer).

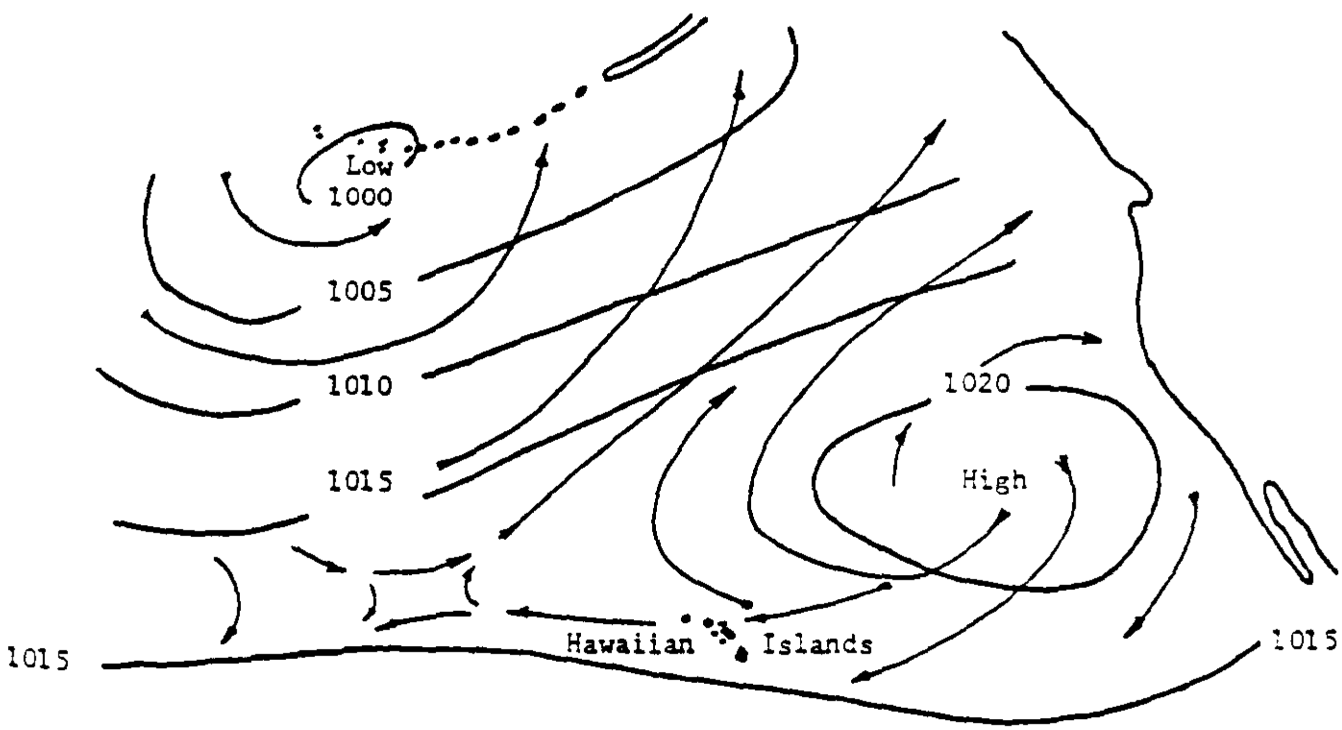

Figure 2b. Mean Pressure (millibars) and Wind Flow in the Eastern and Central North Pacific for January (winter).

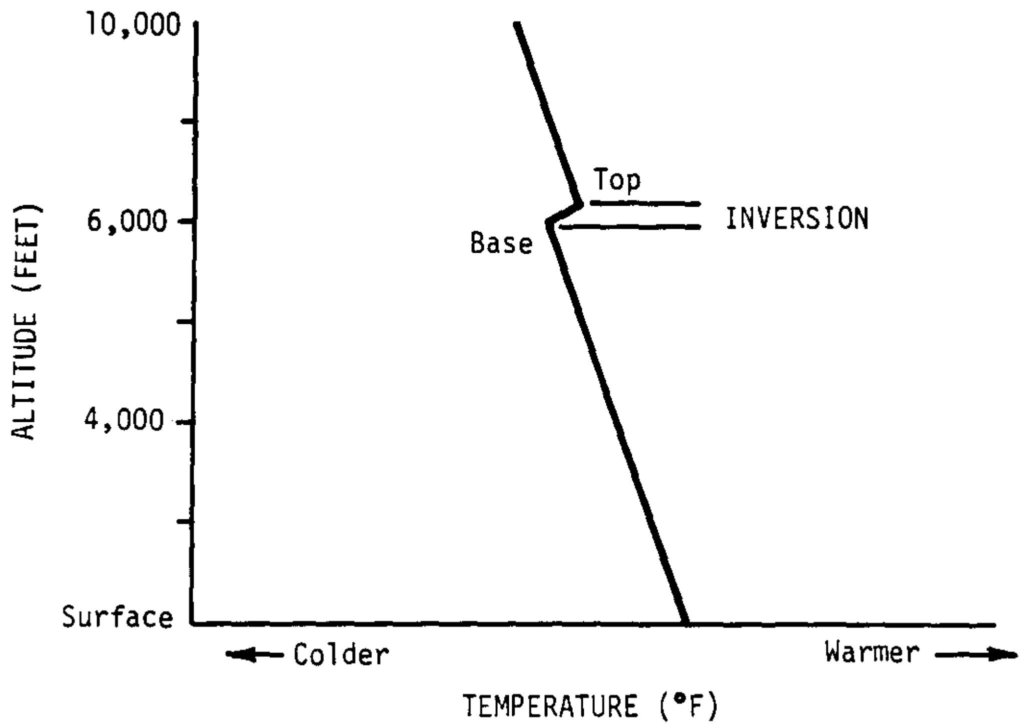

Figure 3a. Trade wind Temperature Inversion

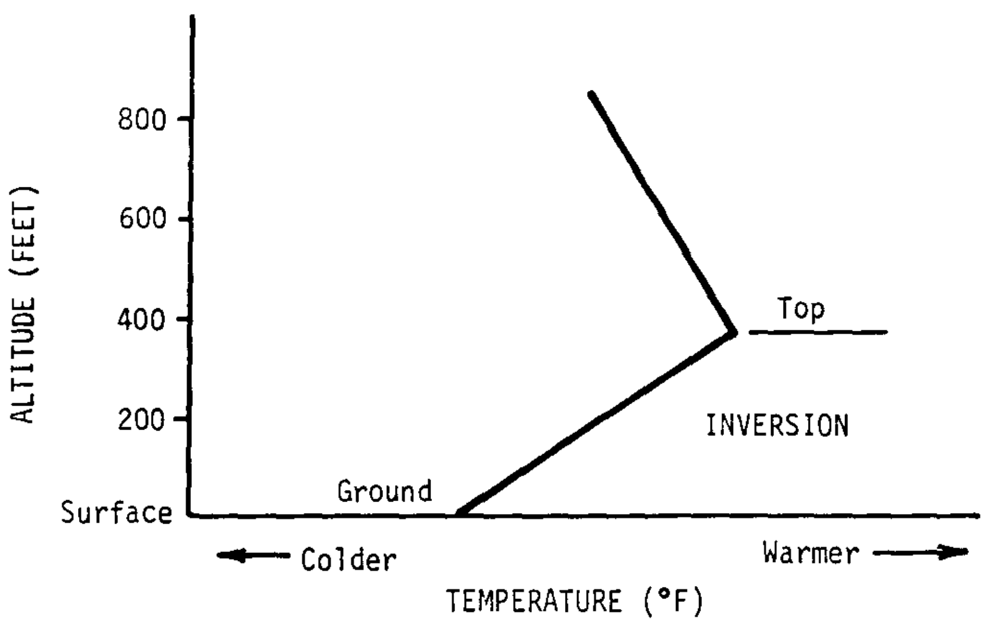

Figure 3b. Ground Temperature Inversion.

Figure 4. Endangered Native Flora

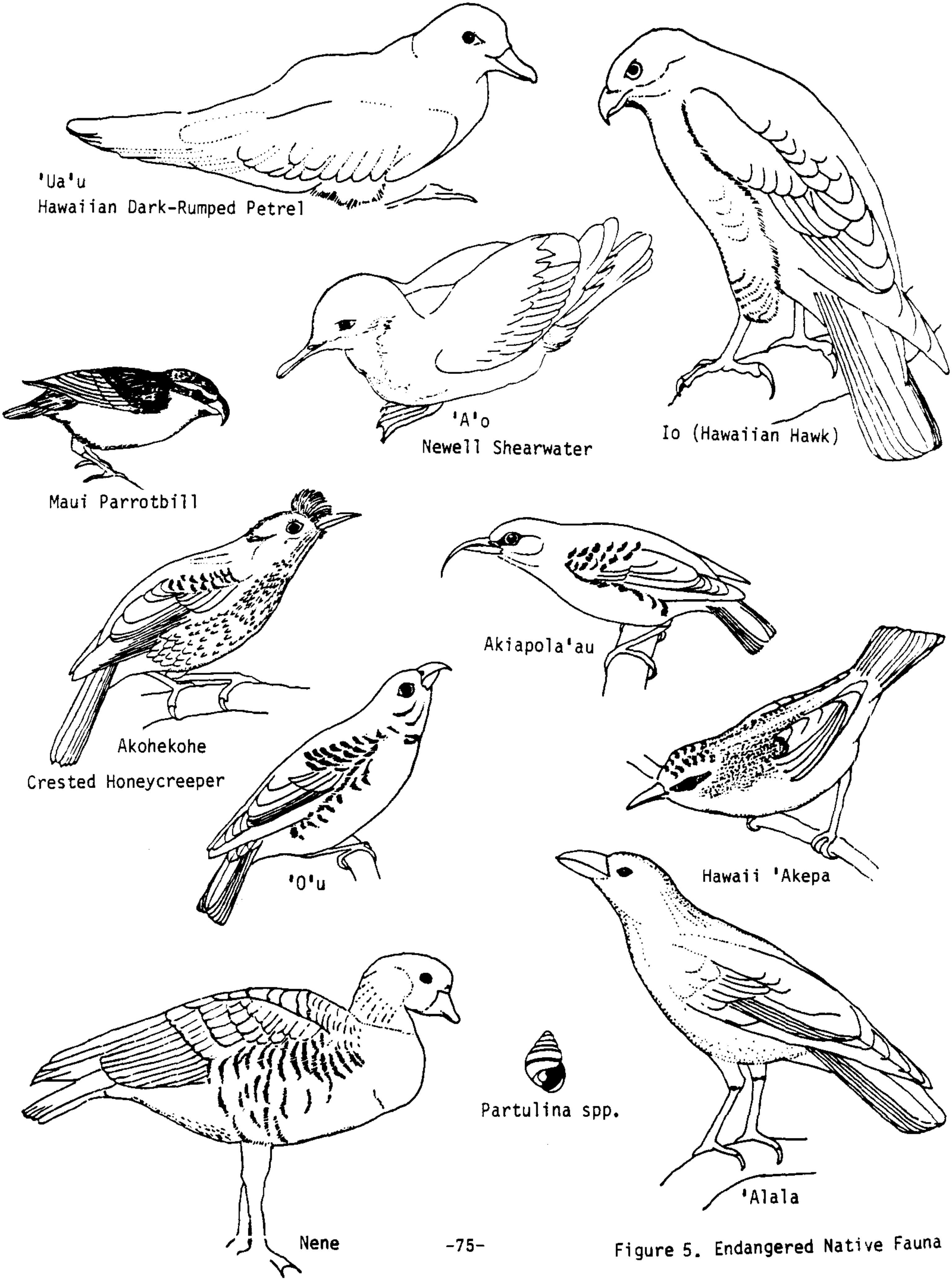

Figure 5. Endangered Native Fauna

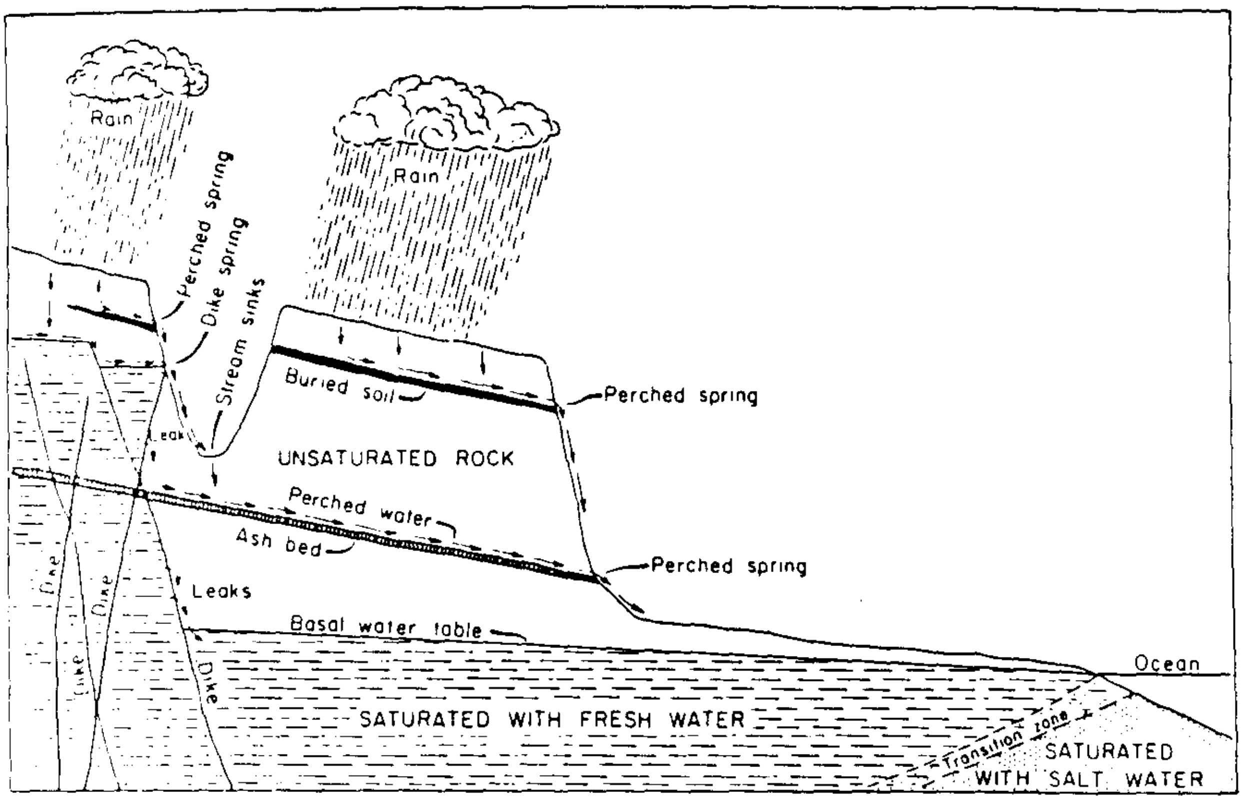

Figure 6. Diagram showing perched water, water confined between dikes, basal water, and pweched and basal springs (Modified after Stearns and Macdonald, 1946).

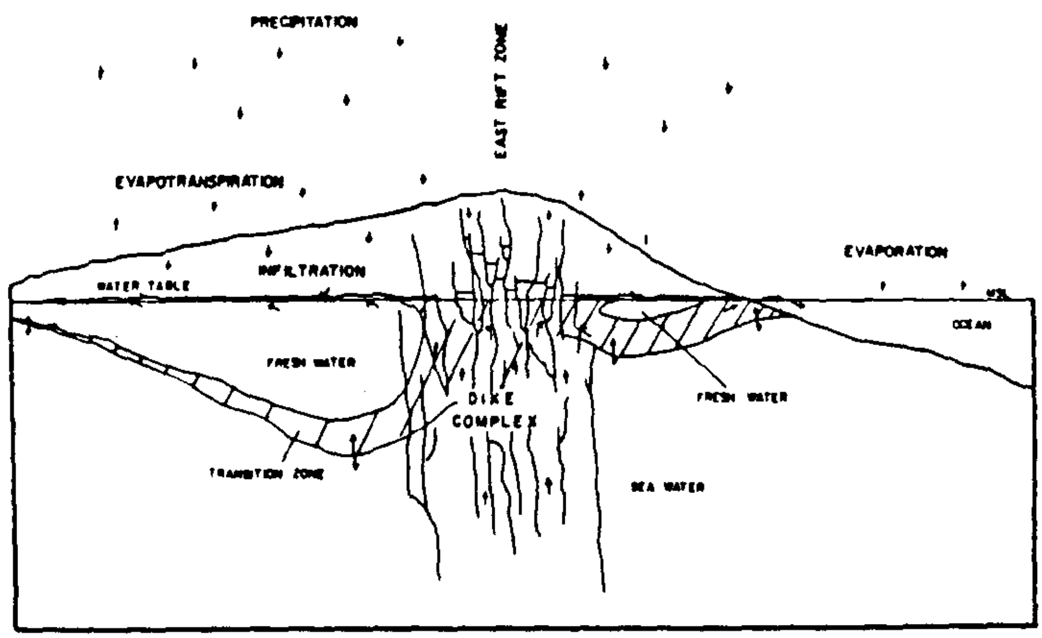

Figure 7. Diagrammatic north-south section through Puna District showing recharge, movement, discharge, storage and subsurface geology of ground water.

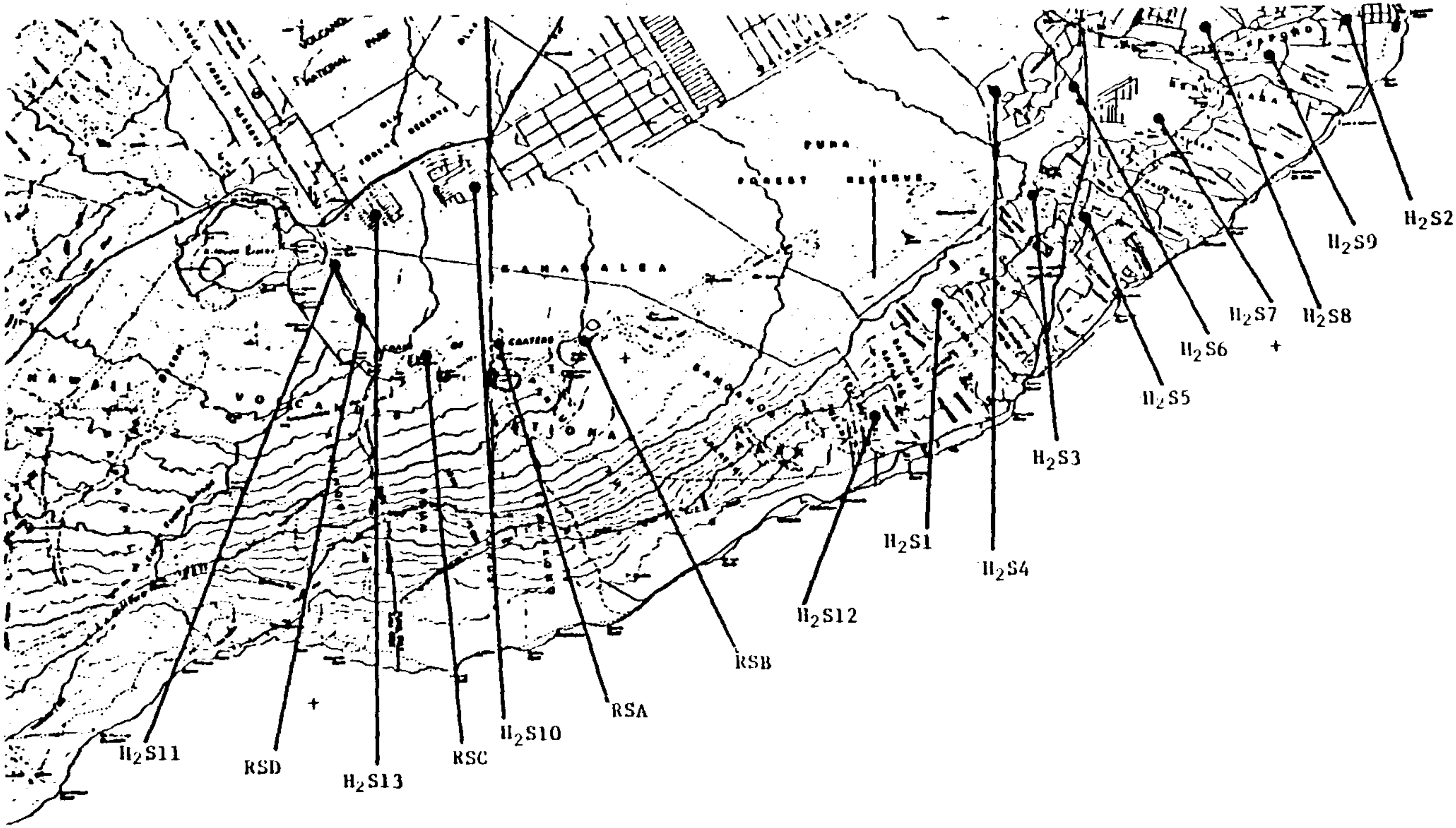

Figure 8. Approximate Loaction of Passive H_2S, Radon, and SFU Monitoring Stations (H_2S1-H_2S13 and RSA-RSD).
(SFU-stacked filter unit)
Source: Houck, 1984

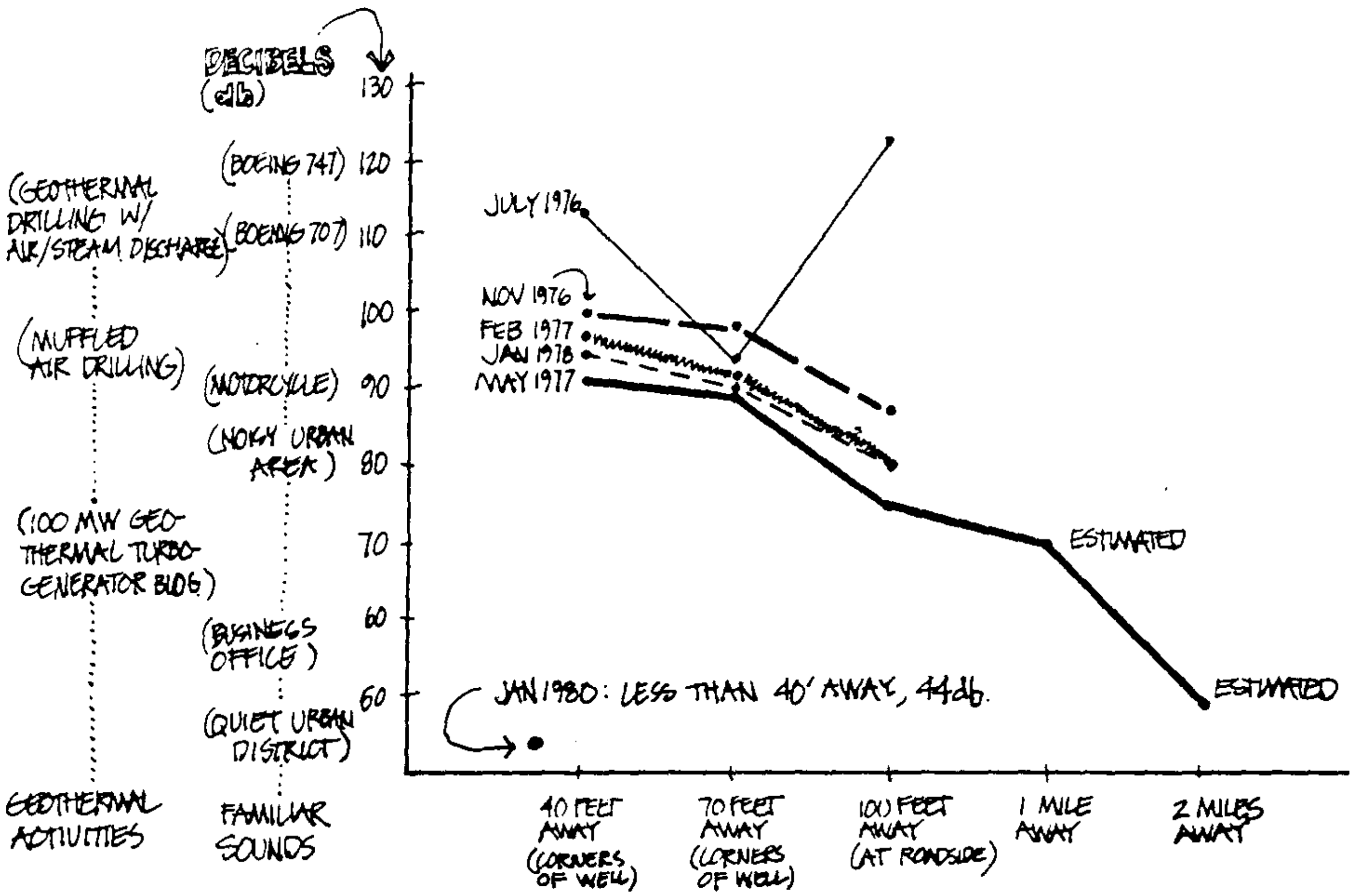

Figure 9. HGP-A Noise Characteristics
(Source: Yen and Iacofano, Geothermal Energy for Hawaii, A Prospectus, 1981).

APPENDIX A

Criteria for Vegetation Categorization from USFWS Mapping Code

and

Dominant Species Composition in Selected Rift Zones

```
Typical          1 2    3  4    5    6
Mapping          \ |    /  |    /    /
Code:             o3Me,2nt(W:tf,ns)sng
```

1. TREE CANOPY CROWN COVER

c = closed canopy, most crowns interlocking	>60% cover
o = open canopy, some or no interlocking crowns	25-60% cover
s = scattered trees	5-25% cover
vs = very scattered trees	<5% cover

2. TREE CANOPY HEIGHT

1 = low scrub trees, monopodial	2-5m tall
2 = scrub trees, moderate stature	5-10m tall
3 = tall stature trees	>10m tall

3. TREE SPECIES COMPOSITION

a) Species name or association abbreviations

Ac = *Acacia koa* (koa)
Al = *Aleurites moluccana* (kukui)
Ep = *Euphorbia* sp. ('akoko)
Me = *Metrosideros polymorpha*
Mr = *Myrica faya* (Firetree)
My = *Myoporum sandwicensis* (naio)
nt = native tree association
Psc = *Psidium cattleianum* (strawberry guava, waiawi)
Sa = *Sapindus saponaria* (Manele; soapberry)
So = *Sophora chrysophylla* (mamane)
xt = introduced tree association

b) Species dominance

Species composition:*	Relative Dominance:
A	only A present
A-B	A and B codominant
A,B	A dominant, B subdominant
A,B-C	A dominant, B and C subdominant
A-B,C	A and B codominant, C subdominant
A-B-C	A,B,C codominant

*Substitute the appropriate species name or association abbreviation for the letters A, B, or C.

4. SPECIES ASSOCIATION TYPE

D = Dry habitat species
M = Mesic habitat species
W = Wet habitat species

5. UNDERSTORY SPECIES COMPOSITION

a) Species name or association abbreviation (Note: Species name abbreviations for trees may also be used if the understory is dominated by individuals of that species, less than 2m tall).

bg = structured bog
mf= matted ferns, Dicranopteris spp., Hicriopteris sp., Sticherous sp.
mg = mixed native-introduced grasses, sedges, or rushes
ng = native grasses
ns = native shrubs
Pm = Passiflora mollisima (banana poka)
tf = treeferns, Cibotium spp. (hapu´u)
xg = introduced grasses, sedges or rushes
xs = introduced shrubs
xx = bare ground (at least 25% of the area)

b) Species dominance (use same format as for tree species)

6. OTHER INFORMATION

bur = recently burned
clr = recently cleared or logged
fum = volcanic fume defoliation
msc = miscellaneous unit - mix of native and introduced species in low elevation areas
pio = pioneer vegetation, seral stage on recent lava flow
sng = many standing dead or defoliated trees

CATEGORY

1	c3, c2, or 3 w/tf, o2 w/tf (o3 if dry or mesic) and 90% or more native species by cover
2	co3, co2 and 75% native canopy (or simply 75% native canopy in non-ohia dominated dry and mesic communities)
2A	s vs 3 or 2, c o s vs 1, o2 w/mf and 50% or more native species by cover
3	Less than 50% native species or [3] Less than 50% ground cover [xx)

Hualalai

Category 1 contains three vegetation compositions. The first type consists of an open canopy of tall Metrosideros polymorpha (Ohia lehua) dominant to moderate size native trees with mesic habitat native shrubs forming the understory. Closed canopies of tall Acacia koa codominant with Metrosideros polymorpha comprise the second composition type. Moderate size native trees and an understory of mesic native shrubs and introduced grasses also occupy these areas. Codominant medium size Sophora chrysophylla (Mamane) and small native trees are scattered throughout the third composition type with dry habitat native shrubs and mixed grasses forming the underbrush.

Category 2A covers a large eastern portion of Hualalai. Dry habitat native shrubs scattered over bare ground comprises the largest section. An area stretching west to northeast of this section also contains very scattered Metrosideros polymorpha of moderate stature codominant with low standing native trees in addition to the underbrush described previously.

Category 2 generally consists of open and closed canopies of moderate to tall Metrosideros polymopha dominant with small to medium size native trees although some large areas also contain Acacia koa. Either dry habitat native shrubs, mesic native shrubs and introduced shrubs and grasses, or wet species of introduced and native shrubs and treeferns form the understory. Pioneer vegetation also grows in some areas.

Category 3 encompasses three compositions of vegetation. The largest section, lying in the western portion of Hualalai, contains scattered tall Metrosideros polymorpha codominant with medium size native trees and tall introduced trees. Mesic introduced grasses comprise the understory. East of this large section lies a plot of scattered, codominant tall Acacia koa, Metrosideros polymorpha, and medium size native trees. The understory consists of mesic introduced grasses. A smallplot of cleared land also exists.

Mauna Loa Southwest Rift

Category 1 contains open and closed canopies of tall Metrosideros polymorpha dominant to native scrub trees and shrubs. The species association type is generally mesic although wet and dry habitat species also exist.

Category 2A contains scattered Metrosideros polymorpha of low to moderate stature codominantly associated in some areas with low lying native trees. Dry habitat native shrubs scattered throughout bare areas are also present.

Category 2 is dominated by open and closed canopies of moderate to tall Metrosideros polymorpha interspersed with low to moderate size native trees and an understory of mesic to dry species of natural shrubs and introduced shrubs and grasses. Large plots of sub-dominant Acacia koa are located on the eastern areas while matted ferns occupy small areas of the Southern portion of the south west rift.

Category 3 contains large plots of bare land scattered with native shrubs. Scattered to very scattered Metrosideros polymorpha of moderate to tall stature occupy smaller areas dispersed throughout the southwest rift. Low to moderate size native trees codominate these areas, and introduced shrubs and grasses as well as native shrubs make up the underbrush. Tall Acacia koa can be found scattered in some areas, codominant with Ohia and native trees.

Mauna Loa East Rift (Upper Piihonua)

Category 1 consists predominantly of closed canopies of tall Metrosideros polymorpha with subdominant association of moderate size native trees. Small plots also contain tall Acacia koa trees. Mesic to wet habitat species of native shrubs and treeferns (Cibotium; hapu'u) comprise the underbrush.

Category 2A contains scattered Metrosideros polymorpha of various sizes codominantly associated in some area with native trees. Wet and mesic species of natural shrubs occupy most of the understory although one small plot contains dry habitat native shrubs and mixed grasses. Large segments of land also have defoliated trees and pioneer vegetation.

Category 2 generally contains open canopies of moderate to tall Metrosideros polymorpha standing alone with mesic species of native shrubs and pioneer vegetation occupying the understory. Some scattered areas also contain moderate size native trees. Beside the native shrubs, matted ferns and defoliated trees occupy small plots of wet areas while mixed grasses exist in some of the mesic and dry habitats.

Category 3 compositions are not found in this section.

Mauna Loa East Rift (Puu Ulaula)

Category 1 contains two types of vegetation compositions. The northern areas consist of closed and open canopies of Acacia koa codominant with Metrosideros polymorhpa. Native trees of moderate height and mesic habitat native shrubs and mixed grasses also occupy these areas. The southern plots contain open canopies of moderate size Metrosideros polymorhpa with an understory of dry habitat native shrubs.

Category 2A generally contains scattered to very scattered Metrosideros polymorpha of low to moderate height. In small areas, very scattered Sophora chrysophylla codominates with Metrosideros polymorpha. Scattered Acacia koa of moderate stature also occupy small plots codominating with native trees. Dry habitat, native shrubs occupy all areas while bare land covers at least 25% of these areas especially in the southern part of the rift zone. Mixed grasses also inhabitat small, scattered plots.

Category 2 compositions are scattered throughout this zone. These areas contain open canopies of moderate size Metrosideros polymorpha. Dry habitat native shrubs and mixed grasses make up the understory.

Category 3 which covers over 50% of this section consists of bare ground with scattered native shrubs.

Mauna Loa East Rift (Kulani)

Category 1 contains two major compositions of vegetation. Large areas, especially in the eastern parts, are dominated by open and closed canopies of tall Metrosideros polymorpha accompanied by moderate size native trees and a wet understory habitat of native shrubs and treeferns. Open and closed canopies of tall Acacia koa codominant with Metrosideros polymorha occupy other large areas. The understory contains either mesic native shrubs and treeferns. Moderate stature native trees also exist in these areas.

Category 2A consists of several different compositions. Most common are the open canopied and scattered Metrosideros polymorpha of low stature with an understory of dry habitat native shrubs scattered along bare ground. Western areas contain this combination. Pioneer vegetation also inhabits some of these areas. Small plots of codominant, scattered Acacia koa of moderate stature and native trees occupy the extreme northwest and southwest parts accompanied by an understory of dry habitat native shrubs and mixed grasses. A long, narrow band running north to northeast consists of bare ground with scattered mesic native shrubs and pioneer vegetation. To the extreme northeast lie several small plots consisting of scattered Metrosideros polymorpha condominant with moderate size native trees. Wet habitat native shrubs and defoliated trees form the understory. The eastern portion of this section features three areas containing introduced trees either dominant or codominant with Metrosideros polymorpha and native trees. Wet species of natural and introduced shrubs and matted ferns inhabit the understory of these areas.

Category 2 contains scattered and closed canopy coverings of moderate to tall Metrosideros polymorpha dominant or codomiant with smaller native trees. Dry to mesic habitats form the Western area underbrush consisting of native shrubs and mixed grasses. Wet species of native shrubs and treeferns inhabit the understory of the eastern plots. Several eastern areas also contain defoliated trees. Acacia koa exist in small plots in the southwest, and pioneer vegetation occupies southern and central plots in this region.

Category 3 consists of large areas of bare ground with scattered native shrubs in the extreme west. Scattered to very scattered Acacia koa of moderate to tall stature codominate smaller plots with native trees and Metrosideros polymorpha. Mesic to dry native shrubs and mixed grasses occupy the understory of these plots. Very scattered, tall Metrosideros dominate a recently cleared plot accompanied by mesic native shrub and introduced shrubs and grasses. A cleared plot and two other unmapped areas are also present.

APPENDIX B

Proposed Revisions to State of Hawaii, Department of Health Administrative Rules, Chapter 11-59, Ambient Air Quality Standards and Chapter 11-60, Air Pollution Control, covering Geothermal Activities.

Chapter 11-59 includes one-hour standard for H_2S of 100 ppb. Chapter 11-60 includes emission standards for geothermal wells and geothermal power plants and H_2S episode levels.

DRAFT—3/22/84

Amendments to Chapter 11-59, Administrative Rules.

1. §11-59-4, Administrative Rules, is amended to read as follows:

"§11-59-4 Ambient air quality standards. (a) [Interpretation.] The numercial ambient air quality standards below limit the time-averaged concentration of specified pollutants dispersed or suspended in the ambient air of the [state] State, but these standards do not in any manner authorize the significant deterioration of existing air quality in any portion of the [state] State.

(b) [Application.] Limiting concentrations specified for a twelve-month period or a calendar quarter shall not be exceeded. Limiting concentrations specified for one-hour, three-hour, eight-hour , and twenty-four-hour periods [less than twelve months] shall not be exceeded more than once in any twelve-month period.

(c) [Carbon monoxide.] In the ambient air the concentration of carbon monoxide measured by a reference method shall not exceed:

(1) An average value of ten milligrams per cubic meter of air during any one-hour period.

(2) An average value of five milligrams per cubic meter of air during any eight-hour period.

(d) [Nitrogen dioxide.] In the ambient air the average concentration of nitrogen dioxide measured by a reference method during any twelve-month period shall not exceed seventy micrograms per cubic meter of air.

(e) [Suspended particulate matter.] In the ambient air the concentration of suspended particulate matter measured by a reference method shall not exceed:

(1) [An average value] A geometric mean of [fifty-five] sixty micrograms per cubic meter of air during any twelve-month period.

(2) An average value of [100] one hundred fifty micrograms per cubic meter of air during any twenty-four-hour period.

(f) [Ozone.] In the ambient air the average concentration of ozone measured by a reference method during any one-hour period shall not exceed [100] one hundred micrograms per cubic meter of air.

(g) [Sulfur dioxide.] In the ambient air the average concentration of sulfur dioxide measured by a reference method shall not exceed:

(1) An average value of [twenty] eighty micrograms per cubic meter of air in any twelve-month period.

(2) An average value of [eighty] three hundred sixty-five micrograms per cubic meter of air in any twenty-four-hour period.

(3) An average value of [400] one thousand three hundred micrograms per cubic meter of air in any three-hour period.

(h) [Lead.] In the ambient air the average concentration of lead measured as elemental lead by a reference method during any calendar quarter shall not exceed 1.5 micrograms per cubic meter of air.

(i) In the ambient air, the concentration of hydrogen sulfide measured by a reference method shall not exceed one hundred thirty-nine micrograms per cubic meter of air in any one-hour period." [Eff. November 29, 1982; am] (Auth: 42 U.S.C. §7410, 7416; 40 C.F.R. Parts 50, 51; HRS §342-3, 342-22) (Imp: 42 U.S.C. §7407, 7409, 7410, 7416; 40 C.F.R. Parts 50, 51; HRS §342-22)

2. Material, except source notes, to be repealed is bracketed. New material is underscored.

3. Additions to update source notes to reflect these amendments are not underscored.

4. These rules shall take effect ten days after filing with the Office of the Lieutenant Governor.

I certify that the foregoing are copies of the rules, drafted in the Ramseyer format pursuant to the requirements of section 91-4.1, Hawaii Revised Statutes, which were adopted on ______________________, and filed with the Office of the Lieutenant Governor.

CHARLES G. CLARK
Director of Health

APPROVED AS TO FORM:

Deputy Attorney General

Amendments to Chapter 11-60, Administrative Rules.

1. Chapter 11-60, Administrative Rules, is amended by adding a new section, 11-60-23.1, to read as follows:

"§11-60-23.1 Geothermal wells. (a) A well as used in this section and section 11-60-23.2 means any well which obtains, or is designed to obtain, a geothermal resource.

(b) Prior to a well being part of a distribution system which supplies a geothermal resource to a power plant which has commenced using the geothermal resource, emissions from the well shall not be in excess of five pounds of particulates, and five pounds of hydrogen sulfide, per one hundred pounds of each respective pollutant in the geothermal resource.

(c) After a well is part of a distribution system which supplies a geothermal resource to a power plant which has commenced using the geothermal resource, emissions from the well of hydrogen sulfide shall not be in excess of two pounds per one hundred pounds of hydrogen sulfide in the geothermal resource.

(d) The owner or operator of a well shall obtain an authority to construct and a permit to operate as follows:

(1) Prior to commencement of well construction, an authority to construct shall be obtained in conformance with subchapter 3, and if applicable, subchapter 4.

(2) Prior to a well being part of a distribution system which supplies geothermal resource to a power plant which has commenced using the geothermal resource, a permit to operate shall be obtained in conformance with subchapter 3.

(e) This section shall be in effect immediately for any well which has not begun actual construction before the effective date of this section. An existing well or one which has begun actual construction before the effective date of this section shall be in compliance with this section by December 31, 1986." [Eff.] (Auth: HRS §§342-3, 342-22, 342-23) (Imp: §§342-3, 342-22, 342-23)

2. Chapter 11-60, Administrative Rules, is amended by adding a new section 11-60-23.2 to read as follows:

"§11-60-23.2 Geothermal power plants. (a) A power plant as used in this section and section 11-60-23.1 means any power plant which uses or is designed to use, a geothermal resource. A power plant as defined shall not include the well(s) supplying the geothermal resource to the power plant.

(b) Hydrogen sulfide emissions from a power plant shall not exceed two pounds per one hundred pounds of hydrogen sulfide in the incoming geothermal resource.

(c) The maximum allowable increase in hydrogen sulfide concentration in the ambient air above natural background level shall be thirty-five ug/m^3 as a one-hour average, considering all stationary sources except geothermal wells in the area affected by the power plant applying for an authority to construct. The maximum allowable increase may be exceeded once per twelve-month period at any one location.

(d) No power plant shall consume any part of the thirty-five ug/m^3 maximum allowable increase until an authority to construct application is certified complete by the director.

(e) The owner or operator of a power plant shall obtain an authority to construct and a permit to operate in conformance with subchapter 3, and if applicable, subchapter 4.

(f) This section shall be in effect immediately for any power plant which has not begun actual construction before the effective date of this section. An existing power plant or one which has begun actual construction before the effective date of this section shall be in compliance with this section by December 31, 1986." [Eff.] (Auth: HRS §§342-3, 342-22, 342-23) (Imp: HRS §§342-3, 342-22, 342-23)

3. §11-60-35, Administrative Rules, is amended and renumbered to read as follows:

"[§11-60-35] §11-60-19 Prevention of air pollution emergency episodes. (a) Notwithstanding any other provision of [the air pollution control regulations, this episode regulation] this chapter, this section is designed to prevent the excessive buildup of air contaminants during air pollution episodes, thereby preventing the occurrence of any emergency due to the effects of these contaminants on the public health.

(b) [Episode criteria.] Conditions justifying the proclamation of an air pollution alert, air pollution warning, or air pollution emergency shall be deemed to exist whenever the director determines that the accumulation of air contaminants in any place is attaining or has attained levels which could, if such levels are sustained or exceeded, lead to a threat to the health of the public. In making this determination, the director [will] shall be guided by the [following] criteria[:] set forth in subsections (c) to (g).

[(1)] (c) "Air pollution forecast": An internal watch by the department shall be actuated by a national weather service advisory that atmospheric stagnation advisory is in effect or the equivalent local forecast of stagnant atmospheric conditions.

[(2)] (d) "Alert": The alert level is that concentration of pollutants at which first stage control action is to begin. An alert [will] shall be declared when any one of the following levels is reached:

[(A)] (1) SO_2 - [800] eight hundred ug/m^3 (0.3 ppm), [24-] twenty-four hour average;

[(B)] (2) Particulate matter - [3.0 COHs or 375] three hundred seventy-five ug/m^3, [24-] twenty-four hour average;

[(C)] (3) SO_2 and particulate matter combined - [product of SO_2, ppm, 24-hour average and COHs equal to 0.2 or] product of SO_2, ug/m^3, [24-] twenty-four hour average and particulate matter, ug/m^3, [24-] twenty-four hour average equal to 65x10^3;

[(D)] (4) CO - [17] seventeen mg/m^3 ([15] fifteen ppm), [8-] eight hour average;

[(E)] (5) [Oxidant] Ozone - [200] four hundred ug/m^3 ([0.1] 0.2 ppm), [1-] one hour average;

[(F)] (6) NO_2 - [1,130] one thousand one hundred thirty ug/m^3 (0.6 ppm), [1-] one hour average; [282] two hundred eight-two ug/m^3 (0.15 ppm), [24-] twenty-four hour average; or

(7) H_2S - one hundred thirty-nine ug/m^3 (0.10 ppm), one hour average;

and meteorological conditions are such that this condition can be expected to continue for twelve or more hours.

[(3)] (e) "Warning": The warning level indicates that air quality is continuing to degrade and that additional abatement actions are necessary. A warning [will] shall be declared when any one of the following levels is reached:

[(A)] (1) SO_2 - [1,600] one thousand six hundred ug/m^3 (0.6 ppm), [24-] twenty-four hour average;

[(B)] (2) Particulate matter - [5.0 COHs or 625] six hundred twenty-five ug/m^3, [24-] twenty-four hour average;

[(C)] (3) SO_2 and particulate matter combined - [product of SO_2, ppm, 24-hour average and COHs equal to 0.8 or] product of SO_2, ug/m^3, [24-] twenty-four hour average and particulate matter, ug/m^3, [24-] twenty-four hour average equal to 261×10^3;

[(D)] (4) CO - [34] thirty-four mg/m^3 (30 ppm), [8-] eight hour average;

[(E)] (5) [Oxidant] Ozone - [800] eight hundred ug/m^3 (0.4 ppm), [1-] one hour average;

[(F)] (6) NO_2 - [2,260] two thousand two hundred sixty ug/m^3 (1.2 ppm), [1-] one hour average; [565] five hundred sixty-five ug/m^3 (0.3 ppm), [24-] twenty-four hour average; or

(7) H_2S - one thousand three hundred ninety ug/m^3 (1.00 ppm), one hour average;

and meteorological conditions are such that this condition can be expected to continue for twelve or more hours.

[(4)] (f) "Emergency": The emergency level is reached when the warning level for a pollutant has been exceeded and:

[(A)] (1) The concentrations of the pollutant are continuing to increase[,]; or

[(B)] (2) The director determines that, because of meteorological or other facts, the concentrations will continue to increase[,]; or

[(C)] (3) When any one of the following levels is reached:

[(i)] (A) SO_2 - [2,100] two thousand one hundred ug/m^3 (0.8 ppm), [24-] twenty-four hour average;

[(ii)] <u>(B)</u> Particulate matter - [7.0 COHs or 875] <u>eight hundred seventy-five</u> ug/m3, [24-] <u>twenty-four</u> hour average<u>;</u>

[(iii)] <u>(C)</u> SO_2 and particulate matter combined—[product of SO_2, ppm, 24-hour average and COHs equal to 1.2 or] product of SO_2, ug/m3, [24-] <u>twenty-four</u> hour average and particulate matter, ug/m3, [24-] <u>twenty-four</u> hour average equal to 393x10^3<u>;</u>

[(iv)] <u>(D)</u> CO - [46] <u>forty-six</u> mg/m3 ([40] <u>forty</u> ppm), [8-] <u>eight</u> hour average<u>;</u>

[(v)] <u>(E)</u> [Oxidant] <u>Ozone</u> - [1,200] <u>one thousand</u> ug/m3 (0.6 ppm), [1-] <u>one</u> hour average<u>;</u>

[(vi)] <u>(F)</u> NO_2 - [3,000] <u>three thousand</u> ug/m3 (1.6 ppm), one [1-] hour average; [750] <u>seven hundred fifty</u> ug/m3 (0.4 ppm), [24-] <u>twenty-four</u> hour average<u>; or</u>

<u>(G)</u> <u>H_2S - thirteen thousand nine hundred ug/m3 (10.0 ppm), one hour average.</u>

[(5)] <u>(g)</u> "Termination": Once declared, any [status] <u>episode level</u> reached by application of these criteria [Will[<u>shall</u> remain in effect until the criteria for that level are no longer met. At [such] <u>that</u> time, the next lower [status] <u>episode level</u> [will] <u>shall</u> be assumed." [Eff. November 29, 1982; am and ren §11-60-19] (Auth: HRS §§342-3, 342-22; 42 U.S.C. §7407, 7410, 7416; 40 C.F.R. Parts 50, 51, 52) (Imp: HRS §§342-3, 342-9, 342-22; 42 U.S.C. §§7407, 7410, 7416; 40 C.F.R. Parts 50, 51, 52)

2. Material, except source notes, to be replaced is bracketed. New material is underscored.

3. Additions to update source notes to reflect these amendments are not underscored.

4. These amendments to Chapter 11-60, Administrative Rules, shall take effect ten days after filing with the Office of the Lieutenant Governor.

I certify that the foregoing are copies of the rules, drafted in the Ramseyer format pursuant to the requirements of section 91-4.1, Hawaii Revised Statutes, which were adopted on ______________________ and filed with the Office of the Lieutenant Governor.

____

CHARLES G. CLARK

Director of Health

APPROVED AS TO FORM:

____

Deputy Attorney General

APPENDIX C

ARCHAEOLOGICAL LITERATURE SEARCH

Kilauea East Rift Zone, (True/Mid Pacific Geothermal Venture, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June, 1082, prepared by Tommy Holmes, April 1982).

Archaeological Literature Research
Tommy Holmes
April 1982

The following is a brief summary of the findings of a documentary literature search on the ahupuaa of Kahauale'a in the Puna District of the island of Hawaii. Attention is given to the entirety of the ahupuaa, though the emphasis is on the mauka portions from about 1,500' to 3,800' elevation, or roughtly three miles inland to the northern terminus of the ahupuaa, just below Kilauea Iki. The present document consists of excerpts from a longer report entitled "A Preliminary Report on the Early History and Archaeology of Kahauale'a, Puna, Hawaii" prepared by Tommy Holmes for the Estate of James Campbell.

TRAILS

In Puna, where canoe landing and launching sites were very few and extremely dangerous, trails held special significance. Given terrain that was alternately rugged lava and thick jungle, Puna residents had no choice but to develop a good trail system over which a great part of trade, communications and transportation occurred.

Several old trails were known to have either passed through Kahauale'a ahupuaa or started at some point outside the area or at the coast and penetrated into Kahauale'a for a certain distance. At least four of these trails traversed Kahauale'a in a rough east-west direction. The trail most makai followed the contour of the coastline just a few feet from the ocean.

A second ancient trail called on maps today the Kalapana or Volcano-Kalapana Trail crossed Kahauale'a a little more than half a mile inland. This was apparently the preferred route in traveling from Puna to the Volcano area (although there were other routes, e.g. Ellis' path).

Coming up on this same trail from Puna, one could continue on to the Volcano or branch off to the right just below Makaopuhi crater to re-enter and recross Kahauale'a at about the 2,700-ft. level. About ten miles inland, this ancient trail, called the Glenwood-Makaopuhi Trail on today's maps, took one through to Keeau and Ola'a and eventually back to Hilo.

The fourth ancient trail, used by Capt. Wilkes' party in 1840, apparently began just to the east of Makaopuhi and traversed Kahauale'a at about the 2,200-ft elevation, passed just north of Kalalua crater and continued down the rift zone.

Hudson also mentions an "old trail across the lava flow south of Makaoiki [a heiau in Kahauale'a about a mile inland].

Makai-mauka trails are shown on U.S. Geological Survey maps compiled in 1912 and 1922. A single trail begins at the coast on the border of Kahauale'a and Kapaahu ahupuaa and runs inland for about three miles in a roughly northerly direction before it branches. The major branch, called the Kapaahu trail, continues into Kahauale'a till about the 1,500-ft. elevation where on the map it terminates. The branch trail fairly closely parallels the Kapaahu trail before it too seems to end at about the same elevation. Most likely one or both trails might have at one time gone considerably further inland serving bird-catchers, canoe-makers, upland farmers, forest product gatherers, travelers, etc. Chester Lyman reported in 1846, taking a trail that appears to have started at the coastal village of Kahauale'a and continued almost due north into the interior of Kahauale'a and back to Hilo.

Indeed there were probably a number of coast-inland trails that accessed the archaeological sites, reported as far as three miles or more inland on neighboring ahupuaa of Kahauale'a. That some would have gone inland up the Kahauale'a corridor is very likely.

The manufacture and export of pulu, the soft, wooly substance found at the base of hapuu ferns, was, according to Thrum, an important industry from 1851 to 1884. Most pulu came from an extensive tract of fern and ohia forest in the Kilauea vicinity. Brigham noted that, "In the early sixties [1860's] the business of picking and packing pulu had become so important that trails cut by the many natives thus employed opened the crater country far more than ever before."

SITES

As mentioned previously, most known sites in Kahauale'a are found quite close to the shore. The most seaward is a canoe ladder site, one of several along the cliff-bound coast of Puna.

Considering the numerous ahupuaa that make up the Puna District, the reported presence of three heiaus in Kahauale'a alone, where many other Puna ahupuaa, often more populous, had none is of some interest.

Located within a couple of hundred yards from the sea adjoining Waikupanaha pond is what Hudson calls Waiaka heiau.

A second heiau, called Punaluu, unquestionably in Kahauale'a, was quite large and complex.

The other reported _heiau_ in Kahauale'a, called by Thrum and Hudson, Makaoiki, was located "about a mile inland from Kupaahu village...in the middle of an aa flow. The adjacent graves are pits sunk in the surface of the flow. Hudson also notes a "former burial cave, a short distance south of site 179 [Makaoiki]. The cave is known as "Kalua Makini".

In the land of Pulama (on old maps the _ahupuaa_ bordering Kahauale'a to the west) Hudson reports a _heiau_, Makaiwa, three miles from the sea. Thrum calls it an "_ipuolono_" or agricultural-type _heiau_. Early Hawaiian scholar S. M. Kamakau says such "_ipuolono_ _heiaus_... temples, or more properly household shrines, were to foster food.

Mention of this _heiau_, though it is not in Kahauale'a, is made here for two reasons.

First: The location of Makaiwa _heiau_ three miles inland, coupled with the location of several other _heiau_ in the southwest Puna area that Hudson places nearly as far inland, strongly suggest that there was significant activity in Kahauale'a and nearby _ahupuaa_ well inland of what was expected when the present study was initiated.

Second: At three miles from shore, Makaiwa _heiau_ and attendant sites are almost to the furthest inland reaches of Pulama which is bounded by a dog-leg of Kahauale'a to the north. In fact, Makaiwa _heiau_ and the other sites are located just a few hundred yards outside Kahauale'a. Hudson notes that in support of the classification of Makaiwa as an "_ipuolono_" _heiau_ are "the many old agricultural workings found nearby [that] indicate that the purpose of the _heiau_ was to protect and fructify the crops". He goes on to say "In the neighborhood of Makaiwa _heiau_ are a number of platforms, house sites, terraces, pens, and walls.

To extrapolate that there might be sites or site complexes a few hundred yards away in Kahauale'a, at the same distance or more inland, is not unreasonable.

UPLAND SITES

It is, in fact, at the elevation of Makaiwa _heiau_ and accompanying sites that Jim Jacobi [personal communication 1982] reported during a bird survey done in the late 1970's, seeing a number of sites. His recall is that these sites were about 1½ to 2 miles below Kalalua Crater situating them in Kahauale'a at about 1200'-1500' elevation, 3½ to 4 miles inland, and by crude calculation relatively near the Makaiwa heiau complex.

Moving up in elevation Mr. Jacobi also recalled seeing a scattering of apparent sites immediately mauka of Kalalua Crater. He also reported part of the ancient trail that Wilkes' party used as still being in evidence in this Kalalua vicinity. Lastly, he recalls seeing certain cultigens, particularly the ti plant, growing in the Kalalua area, further suggesting one time agricultural activity.

Handy recorded information regarding the extent of inland agricultural activity in western Puna in 1935, when there were still individuals living who were familiar with Puna's early history. According to his informants, there is very strong evidence for agricultural activities well inland in Kahauale'a. "Land northeast of Kapa'ahu [that, according to Handy's informants]...used to be covered with plantations" is adjacent and virtually identical in terms of terrain and vegetative cover to the lower mauka portions of Kahauale'a. The description of Kaho'onoho at least 2.5 miles into Kahauale'a's forested interior, and Wala'ohia, also considerably inland, as "the two great forest planting areas in Kahauale'a" rather pointedly suggests upland agricultural activity in Kahauale'a. Similarly, the Kupahua homesteading area, upper Kalapana and upper Kaimu are all three to four miles inland, quite close to Kahauale'a, and similar in nature of terrain and vegetation. Supporting Handy's observations on agricultural activity in western Puna are other references, some already noted and more below.

Two other references, if calculations and assumptions are correct, would place agricultural activities well into Kahauale'a's interior. An "extensive upland taro patch" referred to in 1841 by Capt. Charles Wilkes, head of the U.S. Exploring Expedition, was apparently in Kahauale'a, probably at about 2,000' to 2,200' elevation.

Chester Lyman, who traveled through Puna in 1846 with Rev. Coan, also reports a plantation about five miles inland in Kahauale'a.

At 10 miles he makes note of "a small grass shanty" that could have been a temporary abode for travelers, farmers, or forest product gatherers.

At Panau, a small village near Kahauale'a at about 2,500' elevation and just below Napau crater, there was also agricultural activity. Rev. William Ellis, traveling in 1823 through what appears to be the Panau area, says "The natives ran to a spot in the neighborhood, that had formerly been a plantation, and brought a number of pieces of sugar-cane..."

That there was a permanent village this far inland (about 5 miles) and within minutes of walking time from Kahauale'a, would lead one to suspect that permanent and temporary inhabitants of Panau made regular trips into Kahauale'a for various forest products.

Wilkes, in 1841, says of Panau that "Here many canoes are built and transported to the sea, the trees in the vicinity being large and well adapted to this purpose. What this and other canoe related references suggest is that logging koa trees for canoe hulls and procuring wood for other canoe parts might well have been another inland forest activity within Kahauale'a.

The pre- and early post-contact native forest regime of <u>mauka</u> Kahauale'a, with its extensive <u>ohia</u> canopy provided a near ideal habitat for many of the birds sought after by bird-catchers, <u>kia manu</u>. Feathers from certain birds were made into the highly-prized feather work artifacts of the <u>ali'i</u> - capes, cloaks, helmets, <u>kahili</u>, etc.

Early Hawaiian scholar, N. B. Emerson writing in 1895 about bird-catching considered Kilauea, Puna, and upper Hilo amongst the most desirable bird-catching areas in the islands, implying that Kahauale'a by its location (in Puna and contiguous with Kilauea) and type of vegetative, cover was ideal bird country.

Hudson, while not mentioning Panau by name, says that "a few sites were also found in the upland forest region around Makaopuhi and Napau craters at an elevation of about 2,700 feet 6 miles from the sea". Unfortunately, he does not elaborate further on just where the sites were located or what type they were. He does, though, go on to describe other suspected and known sites, including a <u>pulu</u> factory, and possible religious and habitation sites in the Panau village vicinity.

These sites would all be very close to the border of Kahauale'a. Ellis mentions in 1823 a <u>heiau</u> to Pele near Kilauea-iki which is all but contiguous with the northernmost terminus of Kahauale'a.

Whatever the exact location of these other inland sites the point is firmly made. There was a variety of activities, such as canoe building, agriculture, and birdcatching, in the greater volcano area and regular travel through it along several trails. Kahauale'a <u>mauka</u> was an integral part of the physical and resource bounds of these early inhabitants, temporary workers, and transients. In summary, it would not be unreasonable to expect that there are archaeological sites in the mauka portions of Kahauale'a.

APPENDIX D

ARCHAEOLOGICAL SITES IN GEOTHERMAL RIFT ZONES

Source: Department of Land and Natural Resources, Division of State Parks, Historic Site Section maps and site records as of July, 1984.

Site Number	Description
KILAUEA EAST RIFT ZONE	
10-52-5508	Old Volcano House #42 (National Register)
10-60-7371	Kapapala Ranch Manager's House
10-60-7372	Kapapala Ranch Complex
10-68-7361	Punaluu Landing and Railroad Terminal
10-69-7362	Pahala District
10-68-7370	Site of former Opukahaia House
19-53-7414	Volcano Residential District
10-68-4310	Wailau Complex 1
10-68-4368	Koloa Complex
10-68-4370	Luu Complex
50-10-46-4295	Pualaa Complex II
10-45-7387	Puulaa Congregational Church
50-10-46-4250	Kings Cairns
50-10-46-4251	Kumakahi Grave Sites (State Register)
50-10-46-7492	Lyman Marker
50-10-46-2501	Kapoho Petroglyphs (State Register)
50-10-46-4278	Kahuwai Village Complex
50-10-55-7388	Pahoa District
50-10-46-2500	Kukii Helau
50-10-46-4294	Pualaa Complex I
50-10-46-4254	Kapoho Pt. Platform
50-10-46-4255	S. Kapoho Pt. Complex
50-10-46-2529	MacKenzie Petrogyph Filed (State Register)

MAUNA LOA SOUTHWEST RIFT

10-73-7353	Kahuku Ranch House
10-73-7357	Captain Robert Brown Marker
10-66-7313	Tobacco Barn
10-66-7314	Kona House #10
10-66-7315	Kona House #11
10-66-7316	Hoopuloa Church Site
10-66-7317	I.M. Littorin House
10-66-7318	Kona House #12
10-66-7311	Tobacco Barn & Slaughter House
10-66-7312	McWayne House
10-66-7365	C.Q. Yee Hop Lumber Mills
10-71-2162	Lava Tube Complex (State Register)
10-72-3700	Kalanamauna Upland Complex (State Register)
10-73-7364	Kamoa Homestead House
10-72-2161	Keawaiki Complex (State Register)

MAUNA LOA EAST RIFT ZONE-no sites indicated

HUALALAI-no sites indicated

HALEAKALA EAST

50-50-13-1078	Kalapuni Ko'a (State Register)
50-50-13-1482	Ka'uiki Hill
50-50-13-1485	Kawaipapa Complex (State Register)
50-50-13-107	Waikaloa Platform (State Register)
50-50-13-109	Kauleiula Heiau (State Register)

50-50-13-110	Kauleilepo Heiau (State Register)
50-50-13-1487	Noa Fishponds (State Register)
50-50-13-117	Koahaepali Heiau
50-50-13-522	Aleamai Enclosure (State Register)
50-50-13-573	Ka Iwi O Pele Complex
50-50-13-1491	Kainalimu Enclosure (State Register)

HALEAKALA SOUTHWEST RIFT ZONE

50-50-14-192	Papanuiokane Heiau
50-50-14-1017	Kalua O Lapa Burial Cave
50-50-14-1018	Maonakala Village Complex (State Register)
50-50-14-1021	Poo Kanaka Stone (State Register)
50-50-14-1009	Puu Naio Cave (State Register)
50-50-14-1385	La Perouse Archaeological District (State Register)
50-50-14-1006	Kanaio Mauka Complex (State Register)
50-50-14-1019	Paako Point Ko'a
50-50-15-572	Hoapili Trial (State Register, National Register nomination)
50-50-14-1234	Kaipolohua Cave (State Register)
50-50-14-1235	Cave of Seven Coffins (State Register)

APPENDIX E

VISUAL IMPACT ANALYSIS

(True/Mid Pacific Geothermal Venture, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June 1982).

VISUAL IMPACTS

Concern has been raised about the possible adverse impact that the power plants might have on the vistas within the Hawaii Volcanoes National Park (HVNP). The EIS addresses this issue in Sections 5 and 6. To further document the very minimal visual impacts of the project facilities, an area terrain analysis was made to determine locations outside of the property from which the facilities could be seen. Figure 1 shows the "observer locations" around the Park used in the terrain analysis. Figures 2 through 7 represent visual perspectives from selected observer stations.

Points were chosen at 100-foot elevation increments along the approach road to the Park (Volcano Highway) as well as the nearby public roads in the Park. For each of these points, a view line was calculated from an observer (whose eyes were considered to be 10 feet above the road) to the top of an 80-foot high power plant (A, B, C or D) or a 65-foot high power plant (E). In almost all cases, this view line went below the surface of the ground between the observer and the power plant. Two exceptions to these results occur (1) in the immediate vicinity of the entrance road to the dump site (transfer station) along the Volcano Highway about 2.5 miles east of the Volcano community (Station 7) and (2) a 1,500-foot section of the Chain of Craters Road just as it starts over the Kalanaokuaiki Pali near the turn-off to the Ainahou Ranch where a view corridor is present in which the upper 20 feet (more or less) of a power plant at Site E could be seen.

View lines were also calculated for points along the Napau Crater Trail as well as for other points north of this trail between the trail head and Puu Kamoamoa. The power plants would be visible from about half of the length of this trail as well as from many points in the barren lava fields of the area. Based upon this analysis as well as visual inspection of air photos and maps, it is estimated that one or more power plants may be visible from about 30 percent of the rift zone area north of the trail in this region. To the south of the Napau Trail, the power plants cannot be seen except from a few high points due to the abrupt change of regional slope. Even when the power plants are visible, they are at distances of one to six miles and thus they would not be significant intrusive features with proper design and construction considerations. In no case are they expected to be seen as a silhouette on the horizon, but instead, they would be a feature in the middle to far distant background.

Since the primary visual concern revolves about the possible view of the power plants from publicly accessible view points in the park where large numbers of tourists would likely visit, a series of profiles or visual perspective were constructed to show that the view lines from these points are blocked. Perspectives are shown in Figures 2 to 7. It should be noted that no correction for trees has been incorporated into these perspectives. If the trees are included, only Plant E could be viewed from any nearby road in the park or those immediately outside the park. (Observers on the Mauna Loa strip road at a distance greater than 10 miles may be able to see one or more of the plants once they go above 6,000 feet.) For Plant E, the only areas of visibility from publicly accessible roads are from the Napau Trail parking lot and access road and the portion of Chain of Craters Road immediately to the south of Pauahi Crater and north of the Aina Loa Ranch turnoff.

It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the East Rift Zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, no visible vapors are expected from the cooling towers.

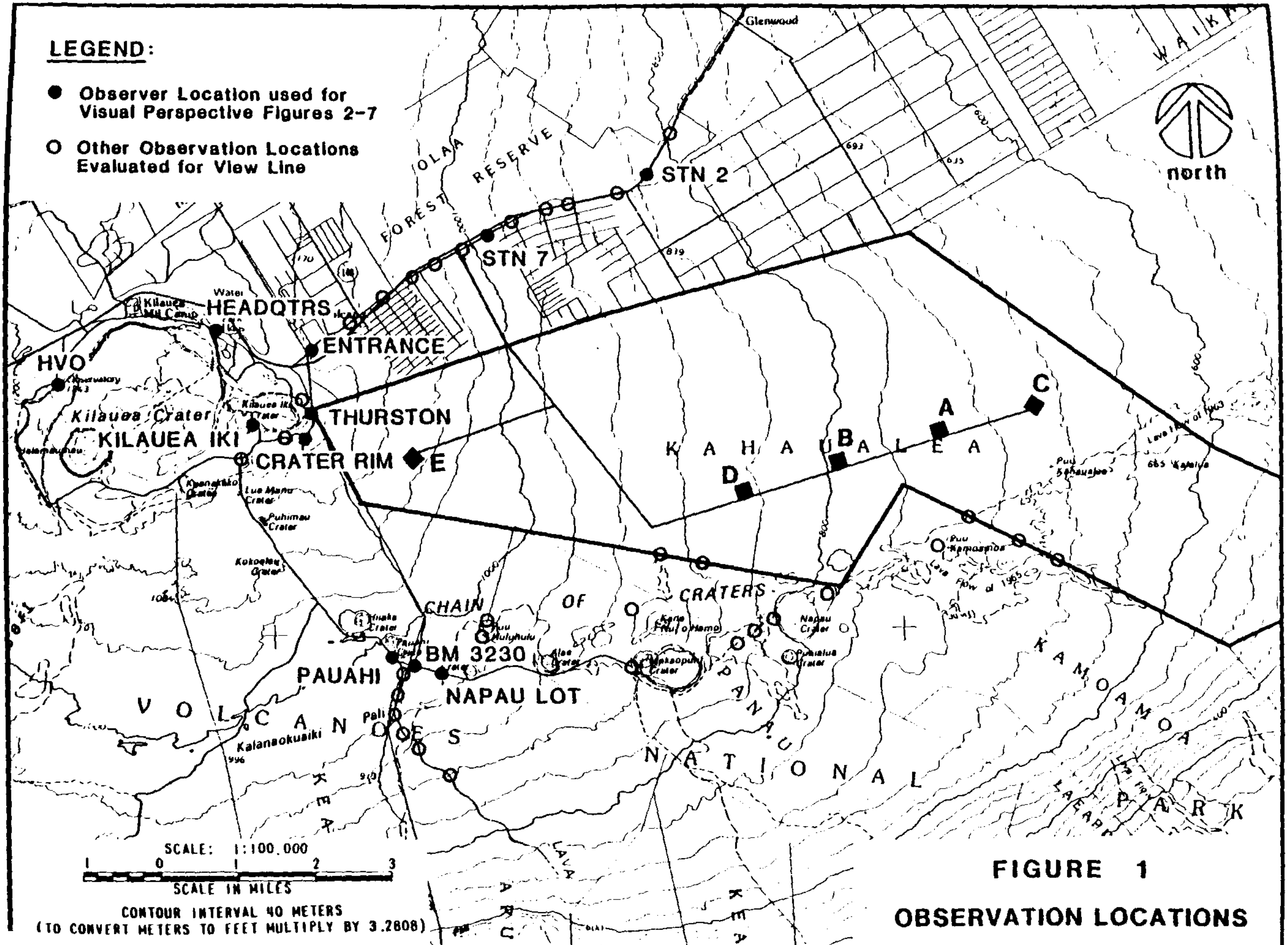

FIGURE 1
OBSERVATION LOCATIONS

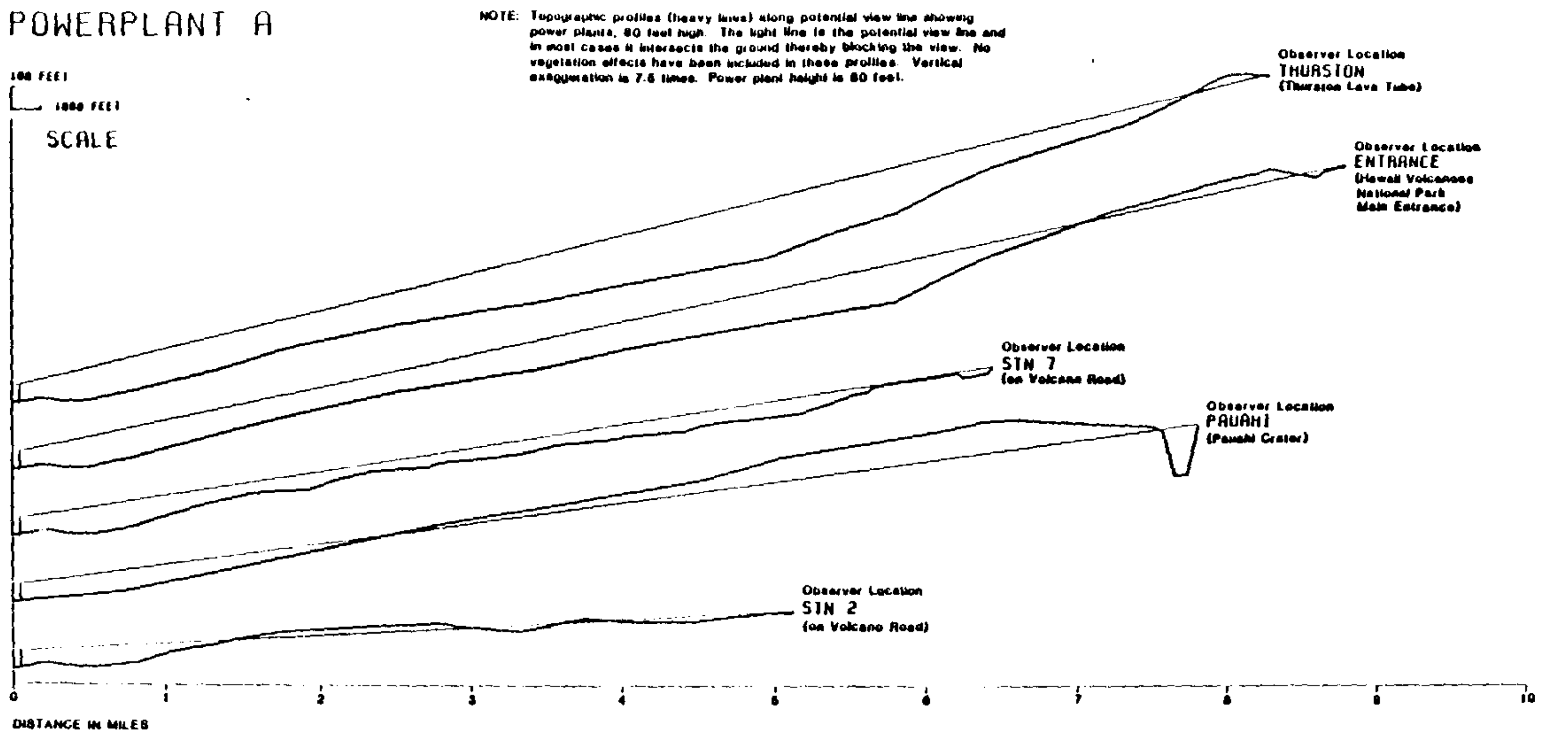

FIGURE 2

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT A

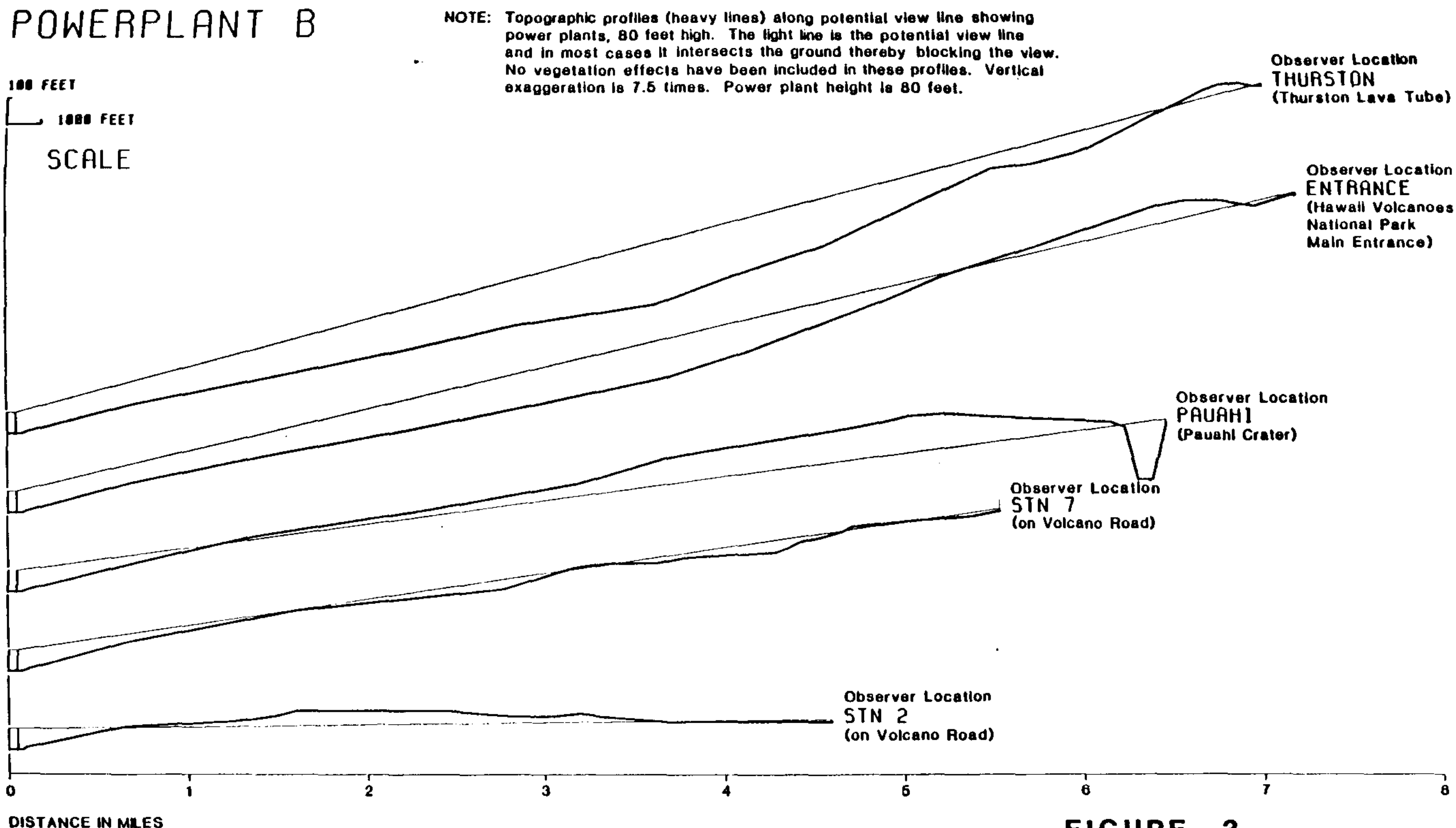

FIGURE 3

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT B

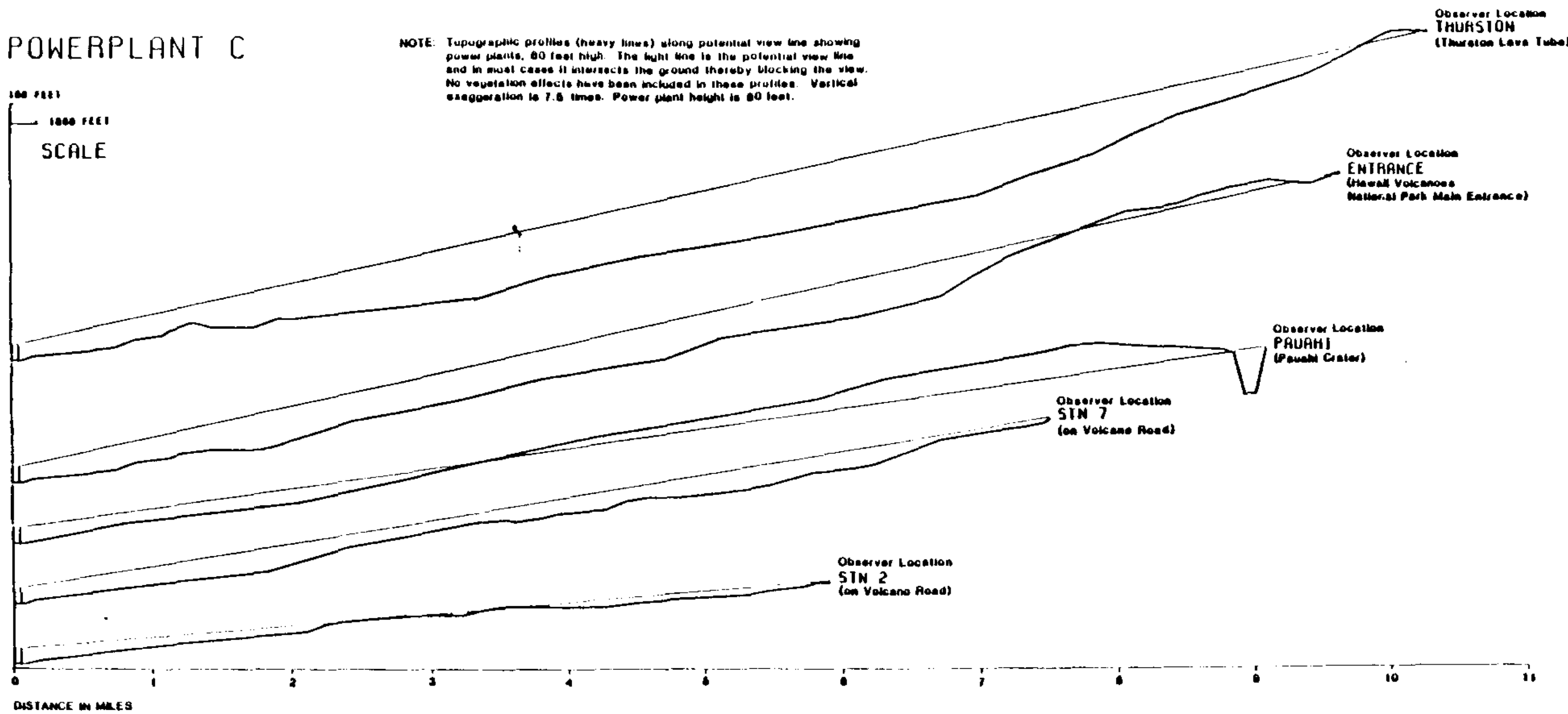

FIGURE 4

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT C

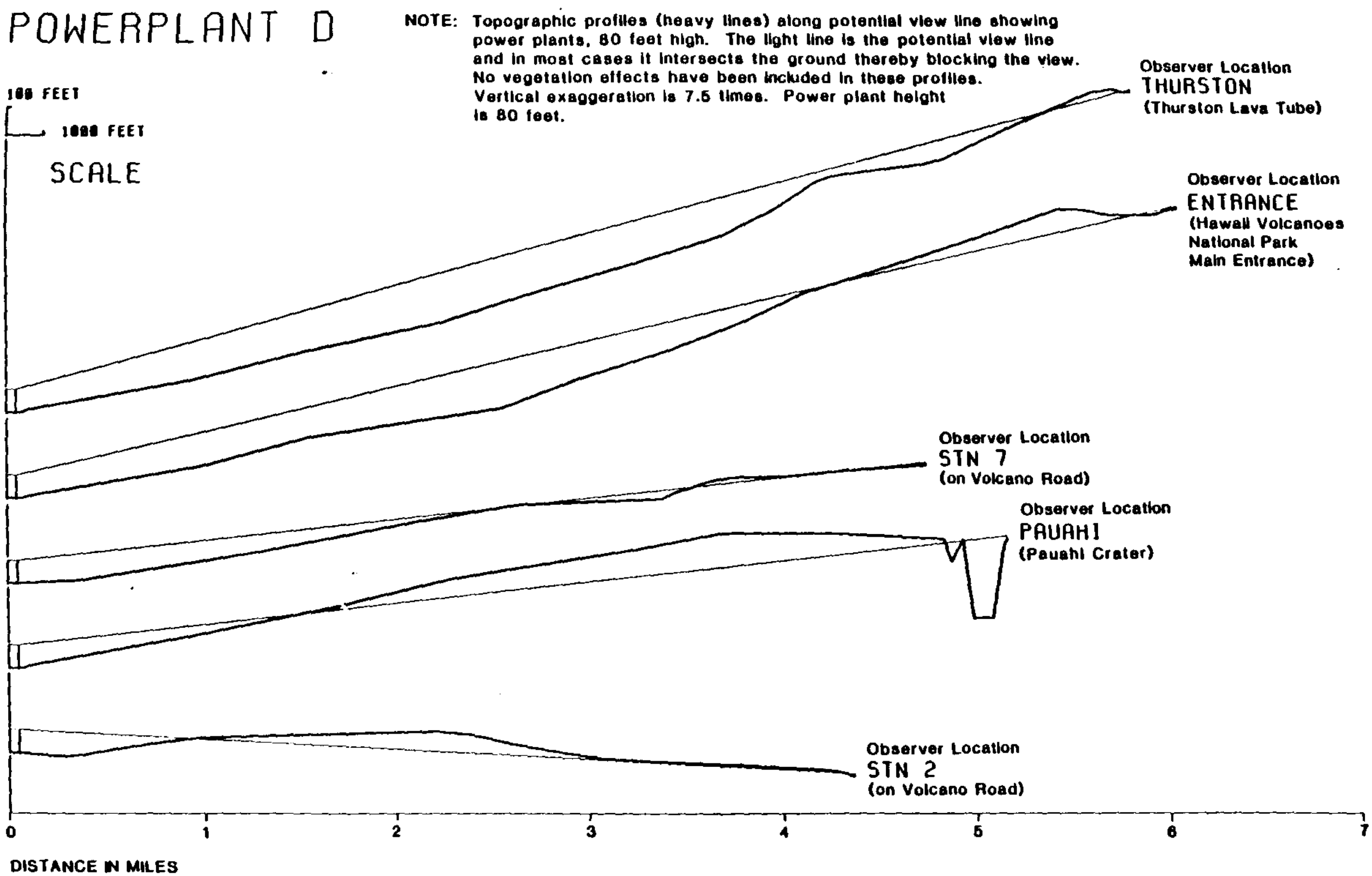

FIGURE 5

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT D

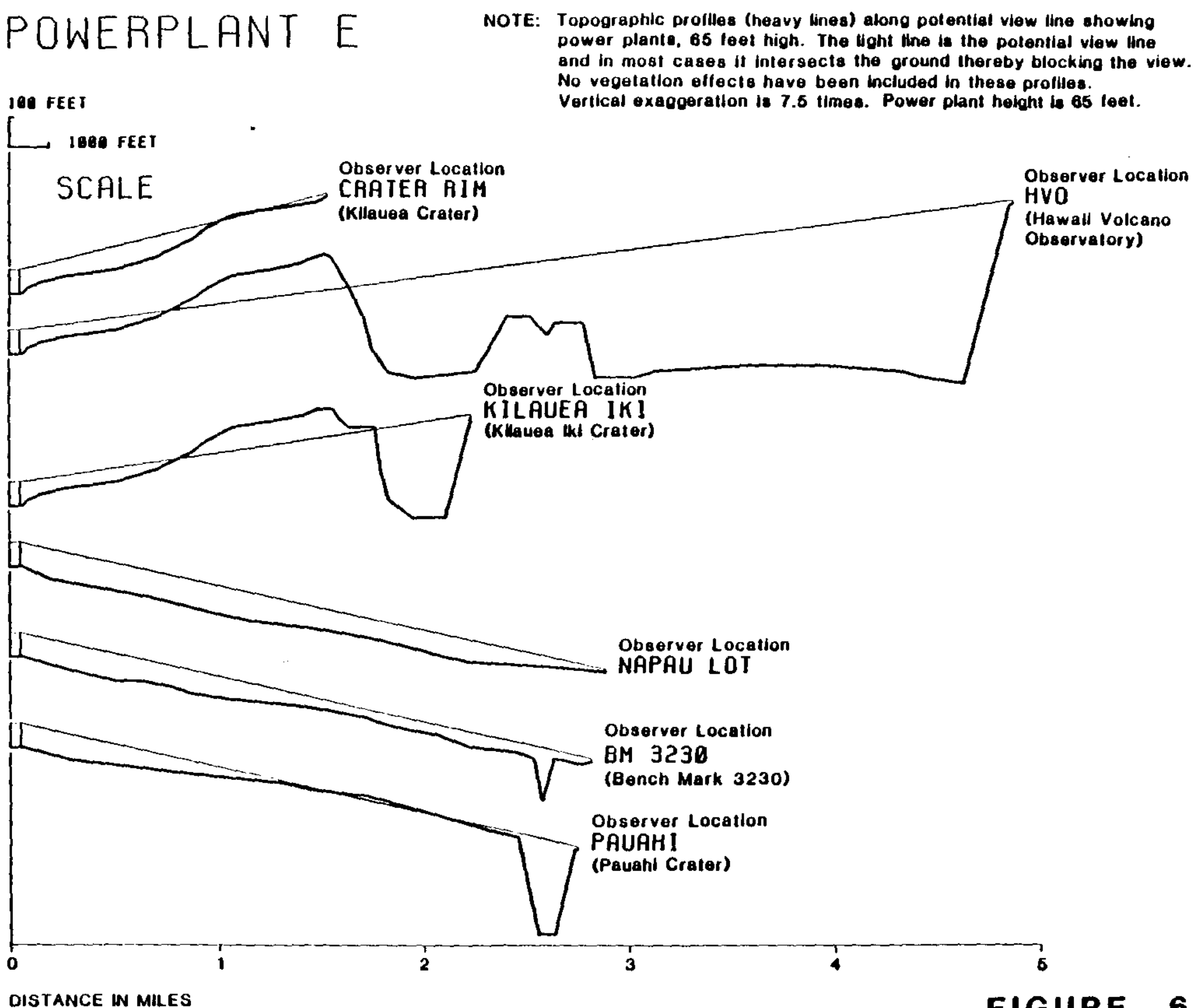

FIGURE 6

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT E

POWERPLANT E

NOTE: Topographic profiles (heavy lines) along potential view line showing power plants, 65 feet high. The light line is the potential view line and in most cases it intersects the ground thereby blocking the view. No vegetation affects have been included in these profiles. Vertical exaggeration is 7.5 times. Power plant height is 65 feet.

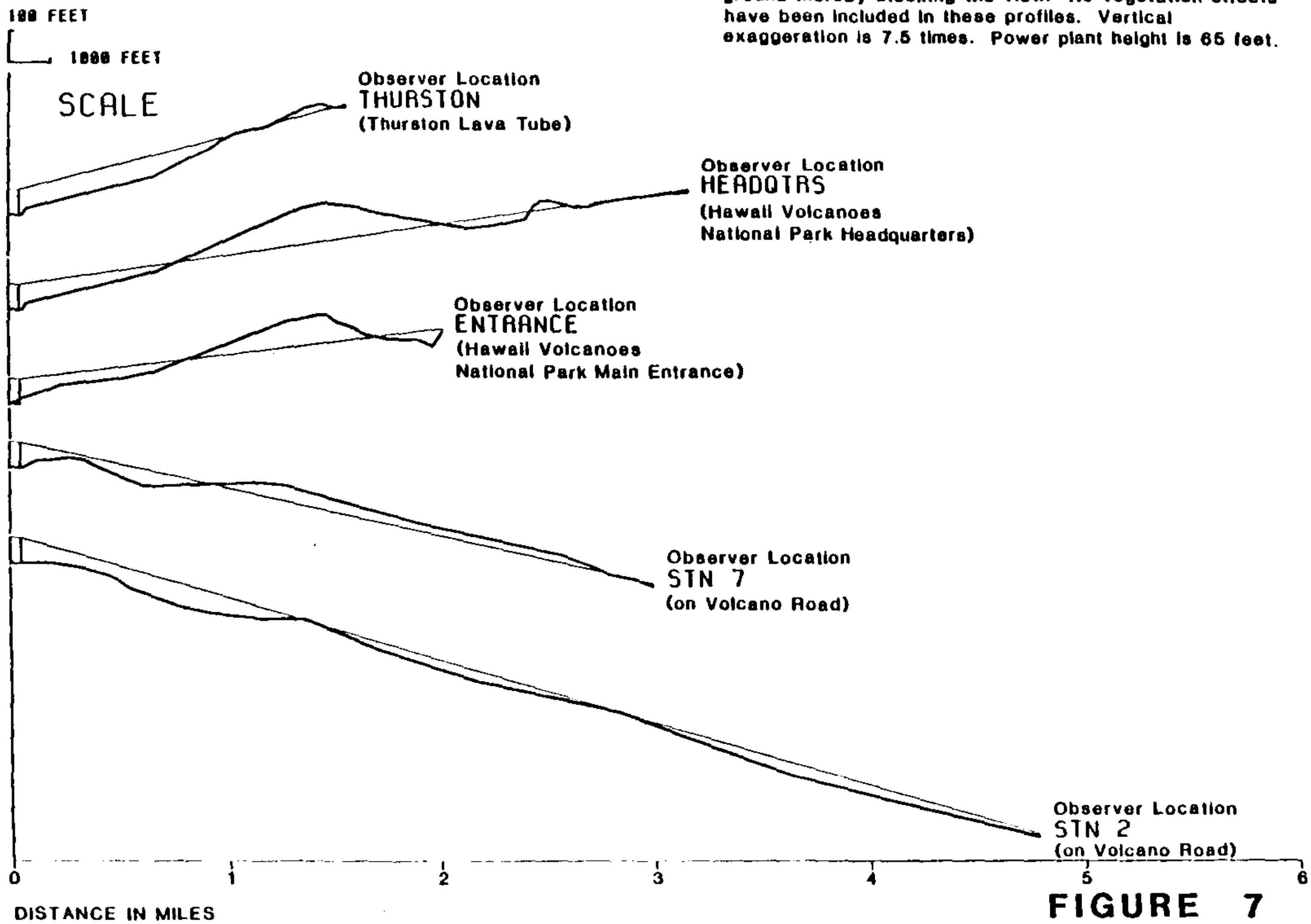

FIGURE 7

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT E

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BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

BOARD OF LAND & NATURAL RESOURCES
STATE OF HAWAII

In the Matter of the Designation of the Kilauea Upper East Rift, Island of Hawaii, as a Geothermal Resource Subzone) G.S. No. 8/27/84-1

PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW, DECISION AND ORDER OF THE DIVISION OF WATER AND LAND DEVELOPMENT

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LIST OF ABBREVIATIONS

BLNR	for	Board of Land and Natural Resources
CDUA	for	Conservation District Use Application
DLNR	for	Department of Land and Natural Resources
Ex.	for	Exhibit
EPA	for	Environmental Protection Agency
Fig	for	Figure
FOF/COL	for	Findings of Fact and Conclusions of Law
HELCO	for	Hawaii Electric Light Company
HRS	for	Hawaii Revised Statutes
MW	for	Megawatts of Electrical Power
No.	for	Number
p.	for	Page
pp.	for	Pages
SLH	for	Session Laws of Hawaii
Tab	for	Table
TMK	for	Tax Map Key
TR	for	Transcript
VCA	for	Volcano Community Association

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the) G.S. No. 8/27/84-1
Designation of the Kilauea)
Upper East Rift, Island of)
Hawaii, as a Geothermal)
Resource Subzone)
)

This matter having come on for a contested case hearing before the Board of Land and Natural Resources of the State Department of Land and Natural Resources, and the Board having considered the testimony and evidence presented with due regard to the qualifications and credibility of the witnesses, makes its Findings of Fact, Conclusions of Law, Decision, and Order in this matter.

A. FINDINGS OF FACT

1. BACKGROUND

1.1 Legal Authority to Designate Geothermal Resource Subzones

1) Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 and provides the legal basis for designating geothermal resource subzones. (State Ex. 4, Introduction)

2) Under Act 296, SLH 1983, the Board of Land and Natural Resources is assigned the responsibility of designating geothermal resource subzone in the State of Hawaii. (Act 296, SLH 1983, Section 1)

3) Section 3 of Act 296, SLH 1983, requires the Board to "adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91." This mandate is provided for under the Administrative Rules, Title 13, Chapter 184, "Designation and Regulation of Geothermal Resource Subzones" of the Department of Land and Natural Resources.

4) Act 151, SLH 1984, clarified various aspects of existing geothermal development activities within the State and the roles of State and County governments.

1.2 Objectives and Provisions of Act 296, SLH 1983

1) In enacting Act 296, SLH 1983, the Legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern and that this interest must be balanced with

interests in preserving Hawaii's unique social and natural environment. (Act 296, SLH 1983, Section 1)

2) The BLNR shall propose areas for potential designation as geothermal resource subzones based upon a preliminary finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in Act 296.

3) Once subzones are established, all geothermal activities including the exploration, development, and production of electrical energy may be conducted only in the designated geothermal resource subzones.

4) Some of the highlights of Act 296, SLH 1983 include:

* Provides for the designation of Geothermal Resource Subzones in each of the four State land use districts--conservation, agriculture, urban, and rural.

* The Board of Land and Natural Resources shall adopt administrative rules to designate geothermal resource subzones.

* The administration of the use of subzones for geothermal development activities shall be governed as follows:

    * BLNR for conservation districts.

    * Existing State and County laws for agriculture, urban, and rural districts.

* No Land Use Commission approval is necessary for the use of subzones.

* Provides for contested case hearing. Upon request, the hearing shall be conducted by the BLNR or County agency prior to the issuance of a geothermal resource permit.

* Any property owner may petition the BLNR to have an area designated as a geothermal resource subzone.

* An EIS is not required for the assessment of areas.

* The BLNR beginning in 1983 shall conduct a county-by-county assessment of potential geothermal resource development areas. The assessment shall be revised or updated at the discretion of the BLNR once every 5 years beginning in 1988. (State Ex. 14, pp. 2, 3)

1.3 Title 13, Chapter 184 Designation and Regulation of Geothermal Resource Subzones

In accordance with Chapters 91 and 205, Hawaii Revised Statutes, and Act 296, SLH 1983, public hearings on the "Proposed Rules for the Designation and Regulation of Geothermal Resource Subzones" were held on May 22, 1984, on all islands by the State Department of Land and Natural Resources.

These rules, formally adopted on July 13, 1984, describe the procedure for initiating the designation of subzones, establishing criteria, providing for the modification and withdrawal of existing subzones, and providing for the regulation of geothermal resource subzones. (State Ex. 14, pp. 3, 4)

1.4 Objectives and Provisions of Act 151, SLH 1984

On May 25, 1984, Act 151, SLH 1984, was signed into law. This Act clarifies the rights of existing lessees holding geothermal mining leases issued by the State or geothermal developers holding exploratory and/or development permits from either the State or County governments. Act 151, SLH 1984, also clarifies the respective roles of the State and County governments in connection with the control of geothermal development within geothermal resource subzones.

* Permits geothermal development activities within urban, rural, agricultural, and conservation land use districts.

* Defines geothermal development activities as "the exploration, development or production of electrical energy from geothermal resources."

* Existing leases within an agricultural district which were issued a special use permit by the County for geothermal development activities, is declared a geothermal resource subzone for the duration of the lease.

* Clarifies the governing jurisdiction of the State and County governments in the geothermal development approval process, and also exempts the permit process from special use permit procedures under section 205-6.

* Clarifies the issuing County agency by defining "appropriate county authority" as the "county planning commission unless some other agency or body is designated by ordinance of the county council."

* Further clarifies the roles of the State and County governments in connection with land use designations, as well as conduct of a permit approval process.

* Mandates that the county authority, in the absence of a mutually agreed upon extension, must provide a decision on a complete and properly filed application within 6 months. (State Ex. 14, p. 4)

1.5 Criteria for Assessment of Potential Geothermal Resource Subzones

Pursuant to the provisions of Act 296, SLH 1983, a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal resource subzones was made which addressed the various factors as given below:

1. The area's potential for the production of geothermal energy;

2. The prospects for the utilization of geothermal energy in the area;

3. The geologic hazards that potential geothermal projects would encounter;

4. Social and environmental impacts;

5. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

6. The potential economic benefits to be derived from geothermal development and potential related industries; and

7. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board considered, where applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226. (State Ex. 14, p. 3)

1.6 Assumptions and Constraints

In implementing the provisions of Act 296, various assumptions were made and constraints were encountered.

1) Methods for assessing the factors or criteria were left to the discretion of BLNR. (Act 296, Section 3)

2) The assessment was on currently available public information. (Act 296, Section 3)

3) Information available varied in its content, detail, and quantum; that is, considerable information was available for some factors while minimal information was available for others.

4) BLNR was responsible to designate geothermal resource subzones with its existing staff since the Legislature, in enacting Act 296, did not provide funds for the implementation of the Act. (State Ex. 4, p. 9)

a. The Division of Water and Land Development was assigned the task by BLNR of compiling information, and providing data to be used in the Board's assessment of the criteria by statute. (State Ex. 4, p. 6)

5) The BLNR was required to separately conduct an assessment of the area described on maps attached to the Board's decision and order, dated February 25, 1983, which was the subject of a CDUA permit, and to make its determination regarding the designation of all or any portion of the area, as a geothermal resource subzone, on or before December 31, 1984.

6) The following DLNR records and files are incorporated in the contested case hearing herein:

a. CDUA No. HA-3/2/82-1463 filed by the Estate of James Campbell.

b. All transcripts for Public Informational Meetings and Public Hearings held as part of the Geothermal Subzoning Process.

7) The procedure used to assess and evaluate potential geothermal resource areas included the following four phases.

Phase I. Statewide Geothermal Resources Assessment

This phase focused upon geotechnical information, its interpretation and analysis of potential geothermal resources on all of the major islands. Due to the time constraint of completing the work by December 1984, available studies were heavily used with minimal new studies and data gathering. First-cut subzones based only on the availability of geothermal resources were mapped to conclude Phase I work.

Phase II. Social, Economic, Environmental, and Hazard Impact Analysis

Impact analysis of social, economic, environmental, and hazard was conducted on the first-cut subzones completed in Phase I. Overlay mapping of the impacts was used extensively to identify highly sensitive impact areas. Adjustments to the first-cut subzones were made to conclude Phase II work.

Phase III. Public Participation and Information

This phase extensively involved communities located in close proximity to the identified subzones. Informational meetings were conducted to explain the technical work and the impact analyses. Comments from the public were solicited and further adjustments to the subzone made.

Phase IV. BLNR Designation of Geothermal Resource Subzones

This phase involved the Board of Land and Natural Resources. Briefing sessions were conducted by the staff on both the technical analysis and the impact analysis. Public input was described and documented. (State Ex. 4, p. 5, testimony of Robert T. Chuck.)

8) The Geothermal Subzoning process is a zoning effort rather than a specific geothermal facility proposal.

9) Subsequent permitting process, mandated in Act 296, will be on a case-by-case, site-by-site basis.

8) Mitigation of impacts will be on a case-by-case basis.

1.7 Chronology (State Ex. 14)

1) February 23, 1984 - Decision and Order issued by BLNR on CDUA No. HA-1463, to allow exploration of the Kahaualea section of the Kilauea East Rift Zone for geothermal resource.

2) June 14, 1983 - Act 296, SLH 1983 relating to geothermal energy signed into law by Governor George R. Ariyoshi.

3) April 16, 18, 1984 - DLNR issued Public Notice requesting information relating to geothermal resources in an effort to maximize the base of available data pertinent to its evaluation of criteria set in Act 296, SLH 1983. Public information meetings on geothermal resource locations and identification of impact issues were held on the following dates at the locations indicated.

May 8, 1984 - Hilo, Hawaii
May 9, 1984 - Kahului, Maui
May 29, 1984 - Hilo, Hawaii
May 30, 1984 - Kahului, Maui
July 10, 1984 - Pahoa Community Council
July 11, 1984 - Volcano Community Association

4) May 25, 1984 - Act 151, SLH 1984 clarifying provisions of Act 296, signed into law.

5) The proposed geothermal resource subzones were published for review by the public and public hearings held on the following dates at the locations indicated.

a. Aug. 7, 1984 - Pahoa Elementary School Cafetorium, Pahoa, Hawaii - 7:00 p.m.

b. Aug. 8, 1984 - Hilo State Office Conference Room, Hilo, Hawaii - 9:00 a.m.

c. Aug. 8, 1984 - Hawaii Volcanoes National Park, Visitor Center Auditorium - 7:00 p.m.

d. Aug. 9, 1984 - Kula Elementary School, Kula Highway, Maui - 7:00 p.m.

6) Aug. 8, 1984 - Initial request for contested case hearing made at public hearing held at Hawaii Volcanoes National Park.

7) Nov. 16, 1984 - BLNR designates Kilauea Lower East Rift Zone and the Haleakala Southwest Rift Zone as Geothermal Resource Subzones.

8) Dec. 31, 1984 - Deadline for BLNR to make decision on designating the the Kilauea Upper East Rift Zone as a geothermal resource subzone pursuant to Act 151, SLH 1984.

9) 1988 - BLNR to conduct a county-by-county assessment of potential geothermal resource areas and revise or update its findings at its discretion. (BLNR is required by law to reassess and revise, as necessary, their findings every five years.)

1.8 Geothermal Subzoning Process (State Ex. 14)

1) Based upon currently available information on geothermal resources, twenty separate areas in the State of Hawaii were identified as having potential geothermal resources. Of these, five sites on the island of Hawaii and two on the island of Maui were determined to have sufficient probability of locating high temperature geothermal resources with the potential of producing electrical energy.

2) High temperature is defined to be greater than 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9,840 feet.

3) After subjecting the seven areas to impact analysis by examining factors on geologic hazards, social and environmental impacts, compatibility with present uses of surrounding land, potential economic benefits, and compatibility with conservation areas, it was concluded that three areas warranted consideration for designation of geothermal resource subzones by the Board of Land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984:

Kilauea Lower East Rift Zone, Island of Hawaii
Kilauea Upper East Rift Zone, Island of Hawaii
Haleakala Southwest Rift Zone, Island of Maui

4) A series of public information meetings were held during the course of the assessment:

May 8, 1984	- Hilo, Hawaii
May 9, 1984	- Kahului, Maui
May 29, 1984	- Hilo, Hawaii
May 30, 1984	- Kahului, Maui
July 10, 1984	- Pahoa Community Council
July 11, 1984	- Volcano Community Association

5) The proposal to designate the three areas (Kilauea Lower East Rift Zone, Kilauea Upper East Rift zone, and Haleakala Southwest Rift Zone) indicated was published in July, 1984 for review by the public, and public hearings were held to receive comments on the proposal:

August 7, 1984	- Pahoa Elementary School Cafetorium Pahoa, Hawaii - 7:00 p.m.
August 8, 1984	- Hilo State Office Conference Room Hilo, Hawaii - 9:00 a.m.
August 8, 1984	- Hawaii Volcanoes National Park Visitor Center Auditorium - 7:00 p.m.
August 9, 1984	- Kula Elementary School Kula Highway, Maui - 7:00 p.m.

6) On November 16, 1984, the Board of Land and Natural Resources designated the Kapoho and Kamaili Sections of the Kilauea Lower East Rift Zone and the Haleakala Southwest Rift Zone as geothermal subzones.

7) The proposal to designate the Kilauea Upper East Rift Zone was not presented at the December 16, 1984 Land Board meeting , in order to comply with requests for a Contested Case Hearing on the proposed designation.

1.9 Description of the Geothermal Resource Subzone, Kilauea Upper East Rift Zone

1) The Kilauea Upper East Rift Zone, Island of Hawaii, is a portion of the Kilauea Rift Zone which extends from Pahala at its southwest and to Kapoho on the east. (State Ex. 14, p. 50)

2) The Kilauea Upper East Rift Zone is designated "Conservation, Urban, and Agriculrtural Districts" by the State Land Use Commission. (State Ex. 10, p. 55)

a. The Kilauea Upper East Rift Zone designated "Conservation District" is further designated as "Protective, Resource, and Limited Subzones."

3) Lands within the Kilauea Upper East Rift Zone are owned by four large area landowners: (State Ex. 10, p. 55)

--United States of America (Hawaii Volcanoes National Park)
--State of Hawaii
--Bishop Estate
--Campbell Estate

4) The Kilauea Upper East Rift Geothermal Resource Subzone is a 5300-acre area located in the Ahupuaa of Kahaualea, encompassing an area between the elevation of 2000 and 3000 feet as shown on Figure 1 and 2 attached hereto. (State Ex. 13 and 14)

5) The Kilauea Upper East Geothermal Resource Subzone is separated by a 2000-foot buffer zone from the Hawaii Volcanoes National Park on the southwest and by a 2000-foot buffer zone from the Wao Kele O Puna Natural Area Reserve on the northeast. Surrounding land uses include the Volcano and Royal Gardens Subdivisions and the forested areas of Kahaualea. (State Ex. 13, p. 71)

6) The Kilauea Upper East Rift Geothermal Resource Subzone is zoned "Conservation District" and "Limited Subzone".

7) The Kilauea Upper East Rift Geothermal Resource Subzone is identified as a portion of TMK: 1-1-01:1 at Kahaualea, Puna, Hawaii containing approximately 5300 acres, as shown on Figure 1 and 2 attached hereto.

8) The Estate of James Campbell claims the fee ownership of the lands within the Kilauea Upper East Rift Geothermal Resource Subzone subject to the reservation of all mineral and metallic mines contained in the original patent and the reservation of the rights of tenants in the land award. (Application for CDUA No. HA-3/2/82-1463)

9) The Kilauea Upper East Rift Geothermal Resource Subzone includes the 800-acre area authorized by the BLNR for exploration by the Estate of James Campbell as shown on Figure 2 attached hereto. (State Ex. 13, p. 71)

1.10 Contested Case Hearings

1) Requirement for contested case hearing:

a. Request for a contested case hearing was made by interested parties whereupon a question arose as to whether a contested case hearing is required by law pursuant to Act 296, SLH 1983, and Act 151, SLH 1984.

b. Because of time constraints--Legislative deadline of December 31, 1984--the Board of Land and Natural Resources in its discretion granted a contested case hearing on the proposed designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone, subject, however, to the right of the Land Board to raise at a later time the issue of whether a contested case hearing is required by law. (DLNR correspondence File - Letter dated 11/15/84 from Susumu Ono to Wendell Y.Y. Ing.)

2) Public Notice:

On November 16 and 21, 1984, notice of a contested case hearing on the proposed designation of a portion of the Kilauea Upper East Rift Zone (Kahaualea) as a geothermal resource subzone was published in the Honolulu Star-Bulletin and the Hawaii Tribune Herald by the Board of Land and Natural Resources.

3) Proceedings:

The contested case hearings on the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone were held by BLNR on December 12, 13, 15, 16, 18, and 19, 1984 in Hilo, Hawaii.

2. SUBSTANTIVE ISSUES

2.1 Potential for Production of Geothermal Energy

2.1.1 Geothermal Resources Technical Committee

1) A Geothermal Resources Technical Committee was formed to assist the Department of Land and Natural Resources in locating geothermal resources for electrical power generation. Participants were selected on the basis of their expertise in the field of geothermal resources in Hawaii. (State Ex. 6, p. xi)

2) A list of the participating committee members and their area of technical expertise is described below: (State Ex. 6, p. 2)

<u>Mr. Manabu Tagomori</u> Area of expertise: Engineering
Chief Water Resources and Flood Control Engineer
Division of Water and Land Development
Department of Land and Natural Resources

<u>Dr. Donald Thomas</u> Area of expertise: Geochemistry
Project Leader, Direct Heat Resources Assessment Project
Hawaii Institute of Geophysics, University of Hawaii

<u>Dr. Bill Chen</u> Area of expertise: Reservoir engineering
Project Manager, HGP-A Wellhead Generator Project
Participated in the Hawaii Geothermal Project as reservoir engineer.
University of Hawaii - Hilo

<u>Mr. Dallas Jackson</u> Area of expertise: Geology and Geophysics
Principle investigator for geoelectrical studies at HVO.
Participated in self-potential research related to geothermal resource.
U.S. Geological Survey, Hawaiian Volcano Observatory.

<u>Dr. James Kauahikaua</u> Area of expertise: Geophysics
Research includes geoelectrical studies such as resistivity surveys related to the identification of geothermal resource.
U.S. Geological Survey

<u>Mr. Daniel Lum</u> Area of expertise: Geology - Hydrology
Head, Geology and Hydrology Section
Division of Water and Land Development
Department of Land and Natural Resources

<u>Dr. Richard Moore</u> Area of expertise: Geology
Chief of "Geology and Petrology of Hualalai Volcano" project.
Research includes geological mapping and the study of geothermal potential on Hualalai and Kilauea Volcanoes.
U.S. Geological Survey, Hawaiian Volcano Observatory.

<u>Dr. John Sinton</u> Area of expertise: Geology
Participated in geological mapping studies for the preliminary State-wide Geothermal Assessment Program.
Hawaii Institute of Geophysics, University of Hawaii

2.1.2 <u>Geothermal Resource Assessment Approach and Criteria</u>

1) The statewide geothermal resource assessment, as mandated by Act 296, SLH 1983, was made on a county-by-county basis and was based on a qualitative interpretation of regional surveys and available exploratory drilling data. (State Ex. 6, p. xi)

2) A series of committee meetings were scheduled during the Statewide Geothermal Resource assessment phase. The first organizational meeting addressed the provisions of Act 296, the administrative rules, plan of study, and the assessment of available information. The committee members were asked to review the bibliography of available information to see if any significant literature had been omitted. It was also agreed that official notice be given to all newspaper agencies inviting the public to submit any additional data relevant to the assessment of potential geothermal resource. Subsequent committee meetings were scheduled to evaluate each island's potential for geothermal resource on a county-by-county basis: (State Ex. 6, p. 3)

Date	Place
March 16, 1984	Honolulu, Hawaii
March 30, 1984	Maui, Hawaii
April 9, 1984	Honolulu, Hawaii
April 18, 19, 1984	Hilo, Hawaii
April 23, 1984	Honolulu, Hawaii
May 11, 1984	Honolulu, Hawaii
June 8, 1984	Honolulu, Hawaii

3) Due to the complexity of Hawaii's geologic structure and the variable nature of groundwater hydrology and geochemistry, the committee did not rely on just one set of data or a single set of rules. Therefore, the assessment of potential for each island was based on a qualitative interpretation of several regional surveys conducted in Hawaii during the last 15 to 20 years and any available deep exploratory drilling data. It was further noted that the use of probability ranges was more appropriate in assessing geothermal resources, in that probabilities would be more accurate than other subjective wording. (State Ex. 6, p. 3)

4) The committee's assessment was based on the following types of geological, geophysical and geochemical data: (State Ex. 6, pp. 3-5)

a. <u>Groundwater temperature data</u>. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

b. <u>Geologic age</u>. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

c. <u>Geochemistry</u>. Groundwater having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered groundwater are anomalously high silica (SiO_2), chloride (Cl) and magnesium (Mg) concentrations. In addition, the evidence of above normal concentrations of trace and volatile elements such as mercury (Hg) and radon (Rn) may indicate leakage of geothermal fluids into nearby rock structures.

d. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of circulating groundwater. Therefore rocks saturated with warm saline groundwater have lower resistivities than rocks saturated with colder groundwater.

e. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above ambient ground temperatures.

f. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

g. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered, have substantially different magnetic properties than normal rock strata.

h. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

i. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

j. Self potential. Self-potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea east rift.

5) The technical members agreed that equal weight would be given to all positive data and the probability areas mapped would be below the 7000-foot elevation due to the limits of current drilling technology. (State Ex. 6, p. 15)

6) One of the most important conditions in a productive geothermal system is a permeable zone that permits adequate recharge of water to the reservoir. This criterion was considered and discussed with respect to all available information. Only exploratory drilling and flow testing of deep exploratory wells can confirm the permeability of an aquifer. (State Ex. 6, p. 12)

7) The conclusions of the Technical Committee demonstrated that no single geothermal exploration technique, except for exploratory drilling, is capable of positively identifying a subsurface geothermal system, instead it is based on several methods resulting in an estimate of geothermal potential for a given area. (State Ex. 6, p. 12)

8) The selection of a high temperature resource area was based on the area's potential for production of electrical energy. The consensus of the Technical Committee was that present day technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than 3 km. (State Ex. 6, p. xii)

9) Upon evaluation of the data and review of the list of percent probabilities, the technical committee identified seven High Temperature Potential Geothermal Resource Areas. The criterion for selection of high temperature resource areas was agreed to be those areas having an assessed probability of at least 25% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km. (State Ex. 6, p. 12)

2.1.3 High Temperature Geothermal Resource Areas

1) The Technical Committee identified seven High Temperature Potential Geothermal Resource Area (greater than 125°C at depths less than 3 km): (State Ex. 6, p. xi)

Area	Percent Probability
Haleakala S.W. Rift Zone, Maui	25% or less
Haleakala East Rift Zone, Maui	25% or less
Hualalai, Hawaii	35% or less
Mauna Loa S.W. Rift Zone, Hawaii	35% or less
Mauna Loa N.E. Rift Zone, Hawaii	35% or less
Kilauea S.W. Rift Zone, Hawaii	Greater than 90%
Kilauea East Rift Zone, Hawaii	Greater than 90%

2) The southern portion of the Kilauea Upper East Rift subzone is located within the 90% probability line as shown in State Ex. 2-B(1). The northern portion of the subzone lies within the area between the 90% and 25% probability lines. (State Ex. 2-B(1))

3) Oral testimony presented by Dr. Don Thomas indicated that there has been a migration of the Kilauea East Rift Zone. Geologic data indicates the presence of older intrusives in the northern area between the 90% and 25% probability lines. This former dike complex is considered to be a feasible heat source for geothermal development, further supported by the oral testimony of Mr. Dallas Jackson. Mr. Jackson stated that magnetic anomalies in this area indicate the presence of a high temperature resource above the Curie pt. (580°C)

within 2 to 4 km depth. Dr. Thomas concluded that the area between the 90% and 25% probability lines was therefore a gradation of percent probability of finding a high temperature resource.

4) Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. Commerically feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. Therefore, on the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, the following probability is estimated: Greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km. (State Ex. 6, p. 8)

2.2 Prospects for the Utilization of Geothermal Energy

1) Private geothermal development on the island of Hawaii has been stimulated by a Request For Proposal (RFP) issued in December 1980 by Hawaii Electric Light Co., Inc. (HELCO) for geothermally generated electrical power to meet their projected power requirements in 1988. (State Testimony of Robert T. Chuck, p. 30)

2) True/Mid-Pacific Geothermal Venture has successfully passed the qualifying Phase I which required preparation of a comprehensive development plan. (State Testimony of Robert T. Chuck, p. 30)

3) On February 25, 1983, the State Board of Land and Natural Resources granted conditional approval of a Conservation District Use Permit to Campbell Estate. The Board's decision allows Campbell Estate to drill up to 8 exploratory wells within a restricted area of the Conservation district or cease exploration when 4 wells show an indication of geothermal resource potential. (State Ex. 3, p. 17)

4) A definite prospect exists for the use of geothermal energy to meet the needs of the public and achieve a step toward the goal of energy self-sufficiency for the State of Hawaii. (State Testimony of Robert T. Chuck, p. 30)

2.3 Geologic Hazards that Potential Geothermal Development Activities would Encounter

2.3.1 Geologic Hazards, Generally

1) The same volcanic activity which provides the ultimate source of geothermal heat is also a hazard to geothermal development. (State Ex. 12, p. vii, CDUA No. HA 3/2/82-1463, p. 4-47)

2) The entire narrow area of the Kilauea east rift zone is hazardous with regard to lava flow burial, pyroclastic fallout, subsidence, and cracking. (State Ex. 12, pp. 32, 35)

3) The entire east rift zone of Kilauea has been volcanically active up to the present time (State Ex. 12, pp. 19, 20, 28, 29, 30) The entire east rift zone has a substantial risk of lava flow burial in areas close to the axis of the rift zone. (State Ex. 12, pp. 30, 32)

4) The general area of the Kilauea upper east rift zone has had 21 eruptions since 1750 (State Ex. 12, p. 19). These eruptions within the upper east rift zone apply to the area between Kilauea's caldera and an imaginary line extending approximately north of Kalapana (State Ex. 12, p. 19; State Ex. 14, p. 40; Note: This imaginary line would separate the 1977 and 1750 flows on Kilauea's east rift zone depicted in State Exhibit 12, p. 28 and as confirmed by the fact that the 1977 flow is included in the upper east rift zone table on p. 19 and the 1750 is included in the lower east rift zone table on p. 20).

2.3.2 Lava Flow Hazards

1) The southern flank of Kilauea's east rift zone is much more prone to be covered by lava flows than is the north flank due to its topography. (State Ex. 12, pp. 29, 30)

2) The Kilauea Upper East Rift Geothermal Resource Subzone is situated in an area just north of the rift zone axis thereby mitigating, to some degree, the hazards which occur with most frequency along the rift zone axis. (State Ex. 14, p. 70)

3) The topography within the Kilauea Upper East Rift Geothermal Subzone rises from approximately 2000 feet in the southeast corner to approximately 3000 feet in the northwest corner (apparent from map, State Exhibit 2B; State Ex. 14, p. 70). While elevated ground should be considered for power plant locations, evidence indicates that selection of high ground is not entirely safe from inundation by lava flows. (State Ex. 6, p. B-53)

4) The area to the north of the present Puu O flows and within the Kilauea Upper East Rift Geothermal Resource Subzone has not been covered by lava within the past 250 years. (State Ex. 12, p. 29; oral testimony of Joseph Kubacki)

5) Approximately 20% of the proposed Kilauea upper east rift geothermal subzone area has been covered by Puu O lava flows prior to phase 24. (Oral testimony of Joseph Kubacki; also apparent by superimposing proposed subzone boundaries upon the historic lava flow map, State Exhibit 2D)

6) All 1983-1984 lava covers approximately 1/3 of the Kilauea upper east rift geothermal subzone area (Written testimony of Richard Moore, VCA, Ex. 21)

7) Approximately 38% of the Kapoho section of the Kilauea lower east rift geothermal subzone has been covered by the 1955 and 1960 lava flows. (Oral testimony of Joseph Kubacki)

8) Approximately 24% of the Kamaili section of the Kilauea Lower East Rift Geothermal Subzone has been covered by the 1955 lava flow. (Oral testimony of Joseph Kubacki)

9) Several construction techniques are available which may mitigate the damage caused by lava flows; these include strategic siting, diversion berms and barriers, enclosed well cellars, evacuation planning, use of "bridge plugs", and decentralization of power plants to lessen the chance that one lava flow could damage a large capacity plant (State Ex. 12, pp. 5, 12). A thorough evaluation of these mitigation alternatives can be provided prior to decisions on future geothermal development permits. (Oral testimony of Joseph Kubacki)

10) Actual development within the vicinity of Puu O may be considered feasible when the volcanic activity at Puu O is determined to have ceased by qualified geologists. (State Ex. 12, p. 18 and State Ex. 13, p. 2)

2.3.3 Hazards from Ground Cracking and Subsidence

1) Cracking and subsidence related to magma movements is concentrated in the volcanic rift zones which are clearly defined and narrow features along the entire Kilauea East Rift zone. (State Ex. 12, pp. 3, 22, 35)

2) Intrusion of magma at Kilauea, sometimes leading to eruptions, often produces offsets of the grounds to great depth along the rifts of the volcano. Such offsets do not necessarily occur on vertical surfaces and the potential for offsetting geothermal well bores drilled in these periodically active areas exist. If cased well bores are cut at depth then pathways to the surface could be opened through which gasses from a deep geothermal system might escape. (Written testimony of Dallas Jackson, VCA, Ex. 7)

3) Most cracks are vertically pitched making it unlikely, but possible, that a vertical crack would intercept a vertical well bore. (State Ex. 12, pp. 3, 4)

4) Hazards from ground cracking and subsidence have been mitigated to an extent by locating the Kilauea Upper East Rift Geothermal Resource subzone north of the rift zone axis. (State Ex. 14, p. 70)

2.3.4 Hazards from Pyroclastic Fallout

1) The weight and depth of fallout can be appreciable as far as even 500 or 1,000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones that may be tens of meters high. Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent. (State Ex. 12, p. 2)

2) In 1959 a blanket of pyroclastic fallout from Kilauea Iki vent in Kilauea's upper east rift zone extended approximately 3000 meters south of the rift. (State Ex. 12, p. 21)

3) Prevailing easterly trade winds are likely to carry fallout originating within the rift zone away from the Kilauea Upper East Rift Geothermal subzone. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact, p. 4-9; State Ex. 14, p. 70)

4) Protecting structures or machinery against damage by pyroclastic fallout might be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong, having a sufficient pitch so that pyroclastic fallout does not accumulate. (State Ex. 12, p. 7)

2.3.5 Hazards from Earthquakes

1) The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 Km southwest of Kalapana. (State Ex. 12, p. 18)

2) Earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983. (State Ex. 12, p. 17)

3) Most earthquakes in Hawaii are volcanic; resulting from near-surface magma movements. They are small in magnitude and usually cause little direct damage. (State Ex. 12, p. 4)

4) Geothermal power plants should be constructed to withstand an earthquake of 7.5 magnitude. (State Ex. 12, p. 8)

2.3.6 Risk of Loss from Geologic Hazards

1) It is assumed that geothermal development investors will bear the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity. Policy regarding assigning and clarifying risks of loss may be implemented by imposing conditions to be met by development investors prior to the granting of a geothermal resource permit by the State (conservation district) or Counties (urban, rural, or agriculture districts). (State Ex. 12, pp. 8, 9)

2.3.7 Predicting the Occurrence of Future Geologic Hazards

Although past history of geologically hazardous events could give some idea of what could occur, it would be difficult or impossible to accurately predict the future occurrence of geologic hazards with any degree of scientific certainty. (State Ex. 12, p. 18; State Ex. 6, p. B-54)

2.4 Social Impacts

The social impact analysis of geothermal resource areas gives emphasis to people's perceptions, attitudes, and concerns regarding geothermal resource development and operation based on available public information. (State Ex. 8, p. vii)

Major social concerns considered were health aspects, noise, lifestyle, culture and community setting, aesthetics, and community input. (State Ex. 8, p. vii)

2.4.1 Health Aspects

1) The health aspects of geothermal resource development involve primarily the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds. (State Ex. 8, p. 1)

2) The study, "Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii," January, 1984, prepared for the U.S. Environmental Protection Agency by Dames & Moore on the Best Available Control Technology (BACT) for emission abatement was utilized in the assessment. (State Ex. 8, p. 3)

3) H_2S, particulate and trace element emission rates were all developed from data gathered at HGP-A and assuming the emission controls described above. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality. Based on these calculations, potential H_2S emissions during normal power plant operations for the development scenarios [25MW and 50MW] described in this report are well below the proposed Hawaii Ambient Air Quality Standard (HAAQS) for H_2S. However, H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emissions control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities. (State Ex. 8, p. 4)

4) Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds. (State Ex. 8, p. 4)

5) The technology for abatement of hydrogen sulfide emissions from the proposed facilities at Kahaualea to acceptable levels is available and the flash-steam cycle appears to be the best plan for the expected resource. The resource at Kahaualea can be abated with present technology to meet the California Standards. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-15)

6) Hydrogen sulfide abatement technology such as the Stretford and burner-scrubber system will lessen the impact on the human and natural environment more than conventional electrical energy production currently in operation today in Hawaii. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-15)

7) Applicant in CDUA No. 1463 speculates that if 250 megawatts proposed for Kahaualea were developed, then that impact on the air quality by replacing the existing oil-fired power plants in the State and by replacing some of the capacity of those oil-fired units, would bring about an improvement in the air quality. The existing 40 megawatt power plant in Hilo is emitting about the same or possibly more toxic gases and sulfur dioxide than the full proposed 250 megawatt geothermal development at Kahaualea. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

8) How effective the various monitoring and abatement programs will be is a function of the size and nature of the geothermal operations, the composition of the geothermal fluids, the state of the technology, and many related factors. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-18)

9) Kilauea Volcano normally emits 200 tons a day of sulfur dioxide and the contribution of sulfur dioxide from the proposed Kahaualea project at full development would only be a fraction of 1 percent of that amount. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-16)

10) The emissions of sulfur, mercury, and other volcanic gases are a continuous process at Kilauea, the rift zone, and the adjacent forest and its inhabitants have long been exposed to lower levels of these potentially toxic emissions and intermittently to higher levels. Exposure to significant levels of geothemal gases are part of the norm for native Hawaiian plants and animals. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-20)

11) "The Puna Community Survey", prepared in 1982 by SMS, Inc. for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, reported that only

one-fifth of the total survey respondents felt they had been affected by the geothermal wells in Puna, on the Hawaii Island. (State Ex. 8, p. vii)

12) In the "Puna Speaks" case, where HGP-A shutdown was requested by some Puna residents, the U.S. District Court Judge ruled that the plaintiffs did not prove their case in suit as no causation was established between the well emissions and alleged maladies. (State Ex. 8, p. 3)

2.4.2 Noise Aspects

1) Although noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor which can be controlled and monitored. (State Ex. 8, p. 4)

2) The source of noise impact from the proposed Kahaualea Geothermal Project would arise from (a) construction of roads, pipelines, and buildings; (b) geothermal well-drilling and testing or venting; and (c) geothermal power plant operations. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

3) During the initial phases of field development, persons in the immediate vicinity of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site. (State Ex. 11, p. 8)

4) Construction noise level data did not receive much scrutiny or attention at the hearing nor in the EIS pertaining to CDUA No. 1463. Noise generated by construction activity will involve the use of standard construction equipment such as local bulldozers, trucks, and graders operating in the same manner, and over a limited time period as any other typical project. No unusual noise events of long duration are involved. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-29)

5) Within 100 feet of the drill rig, noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler. (State Ex. 11, p. 8)

6) The use of venting noise abatement procedures such as portable or in-place rock mufflers, the noise levels from the initial drill site to the Fern Forest Vacation Estates should be in the range of inaudibility in most cases, to a maximum of 36 dBA under worst case conditions. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-27)

7) Noise levels projected for the anticipated power plants are expected to be low and should result in slightly audible or inaudible levels of most receptor sites. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

8) Power plants A, B, C, and D proposed under CDUA No. 1463 will be inaudible at all camping sites, picnic areas and trails in the Hawaii Volcanoes National Park with the exception of times when the trade winds have a northerly component and noise levels to 32 dBA may be audible at the closest end of Napau Crater. The four power plants will be completely inaudible at all Hawaii Volcanoes National Park features near the Kilauea Caldera area. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-28)

9) Applicant in CDUA No. 1463 assures the Board that buildings and barriers can be designed to optimize the orientation and degree of closure to contain noises from the turbine, genrator and transformers. Cooling towers have not proven to be dominant noise sources in geothermal plants. Taking all major noise sources into account, the continuous noise level of 75 dBA at 100 feet is considered readily achievable for power plants at Kahaualea. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-30)

10) Ambient or background noise refers to the noise levels which presently exist in the environs of the project site of CDUA No. 1463 at locations where people reside, play or work and sometimes is produced by the people themselves. The existing exterior ambient noise levels at residences in the environs of the proposed geothermal operations are dictated largely by the sounds of nature and by the traffic on Volcano Highway as well as by traffic on local roads. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-22)

11) The impact and intrusiveness of the noise of geothermal operations at Kahaualea and the surrounding environs is dependent on the meteorological conditions; the intensity of the noise source; the sound propagation conditions existing between the source and listener; the ambient or background noise at the receptor; and the activity at the receptor area at the time of the noise event. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

12) As the project progresses, nosie propagation information will be obtained and will serve as guidance for the design of noise mitigation meausres required of the power plants, particularly for power plants located closer to noise sensitive residential and park areas. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-29)

13) Ambient noise levels are often expressed as day-night noise levels (Ldn) where a 10 dB reduction is given for noise levels during the nighttime period between generally 10 p.m. to 7 a.m. The long-range strategies of the Environmental Protection Agency (EPA)

are to achieve a goal of 55 Ldn (45 dBA nighttime) which will ensure protection of public health and welfare from all adverse effects of noise based on present knowledge. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-22)

14) The EPA "Protection Noise Level" document's recommended levels are levels defined by a negotiated scientific consensus that was developed without concern for economic and technological feasibility, is intentionally conservative to protect the most sensitive portion of the American population, and includes an additional margin of safety. The levels should be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-23)

15) In May of 1981, the County of Hawaii Planning Department issued a set of "Geothermal Noise Level Guidelines" to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. (State Ex. 8, p. 5)

16) The County of Hawaii geothermal noise level guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted. (State Ex. 11, p. 8)

17) The Applicant of CDUA No. 1463 has committed to complying with the Geothermal Noise Level Guidelines of the Hawaii County Planning Department ("Guidelines"). The "Guidelines" specify that the "acceptable geothermal noise guidelines should be at a level which reasonably assumes that the Environmentl Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met" and that the sound level measurements should take place at the affected residential receptors that may be impacted by the geothermal operation. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-22)

18) The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. (State Ex. 11, p. 8)

19) The type of housing found in Fern Foret, Volcano Village, etc., will result in noise reduction from outside to inside of at least 15 dB. Thus, an outside noise level of 45 dBA will reduce to an inside level of 30 dBA or less, which is less than the EPA's 32 dBA level for sleep modification. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-23)

2.4.3 Lifestyle, Culture, and Community Setting

1) The Puna area has the most information and the input to-date on these aspects related to geothermal development and may be applicable to other localities. Each community, however, will have its own unique background and perceptions and goals. Each community should in the process of considering geothermal resource development contribute its own input into the assessments. (State Ex. 8, p. 7)

2) In April 1980, 11,775 persons were living in Puna which constituted roughly 13 percent of the Big Island's population. In district size and population, Puna ranks third after South Hilo and North Kona. Puna's population density of 23 persons per square mile is the same for the County of Hawaii as a whole. Within the Puna District, roughtly 20 percent (2,246) of the residents were living in the towns of Keeau, Mountain View, and Pahoa. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-44)

One of the survey questions discussed in the "Assessment of Geothermal Development Impact on Aboriginal Hawaiians" by the Puna Hui Ohana, regarding Community attitudes toward geothermal development asked respondents how they felt about the quality of life in Puna at the present time. The large majority responded that they were happy with the present quality of life in Puna, while only 9.5% were unhappy and 8.6% were neither happy nor unhappy. (State Ex. 8, p. 8)

3) The EIS filed pursuant to CDUA No. HA-1463 indicates the subject parcel is generally in an unused, undeveloped state. In its present state, it provides open space to the residents of adjacent residential and agricultural subdivisions and also to the visitors of the Hawaii Volcanoes National Park. The relatively untouched native forest provides the scientific community with a field laboratory. The subject property is presently unused as an economic entity as there are neither residents nor any economic activities on the parcel. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-42)

4) Little of Kahaualea lends itself to intensive agricultural activities. Most of the population and related activities occurred in the makai sections. Reported agricultural areas in Kahaualea were located approximately a mile to 1-1/2 miles southeast and below the rift zone. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-40)

5) No archaeological sites, native cultigens or lava tubes that could have served as shelters were observed either along the proposed access route or the KA-1. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-40)

6) There are no known archaeological sites within the Kilauea Upper East Rift Zone. (State Ex. 10, p. 55)

7) There have been no studies of the impact of exploration on nitve Hawaiian cultural or religious values and practices. The Board and parties did conduct a site visit accompanied by a guide knowledgeable about the traditions and practices in the area on December 11, 1982. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-41)

8) Property in the upper East Rift Zone is owned by four large area landowners, the United States of America (Hawaii Volcanoes National Park), the State of Hawaii, Bishop Estate, and Campbell Estate. Smaller holdings owned by various individuals are found in the roayl Gardens Subdivision along the coast and in urban and agricultural zoned areas in the Kilauea-Olaa area at the mauka boundary of the rift zone. (State Ex. 10, p. 55)

9) The location of the proposed geothermal resource subzone is set back away from the Volcano community, Hawaii Volcanoes National Park boundaries, and the Wao Kele O Puna Natural Area Reserve. (State Ex. 14, p. 52)

10) The small magnitude of change in lifestyle and social inter-action that may be brought about by new residents may be a small part of the lifestyle, culture and community and traffic changes already taking place in the area as a result of the influx of new residents in recent years. (State Ex. 8, p. 14)

2.4.4 Aesthetics

1) "The Puna Community Survey" by SMS Research Inc. reported that of the negative impacts perceived relating to the geothermal well, 5% felt that it "looks bad". The area respondents with the greatest percentage of citing of the aesthetic aspect were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance. (State Ex. 8, p. 10)

2) The Kahaualea parcel is relatively untouched by man and remote from residential populations. There are no residents or structures in Kahaualea and the distance to the nearest home is approximately 2-1/2 miles. Its open vistas include natural topographic features, heavily wooded forests, grassy slopes and barren lava flows. The Kahaualea property is generally flat with a gently sloping terrain of densely vegetated 'ohi'a forest, except in those rift zone areas where lava flows have destroyed the vegetation. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-31)

3) Although in some areas with potential geothermal resource development the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--consideration of aesthetic

aspects should include careful siting, tasteful design, and effective landscaping. (State Ex. 8, p. 10)

4) Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures and towers and plants with colors to blend in with the natural setting. (State Ex. 8, p. 10)

5) Estimates of visual impact are accomplished by preparing an area wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen. A terrain analysis of visual impacts was completed for the preparation of the Kahauale'a Environmental Impact Statement (Kahauale'a Revised EIS, June 1982). (State Ex. 10, p. 36)

6) Points were chosen at 100-foot elevation increments along the approach road to the Park (Volcano Highway) as well as the nearby public roads in the Park. For each of these points, a view line was calculated from an observer (whose eyes were considered to be 10 feet above the road) to the top of an 80-foot high power plant (A, B, C or D) or a 65-foot high power plant (E). In almost all cases, this view line went below the surface of the ground between the observer and the power plant. (State Ex. 10, p. E-3)

7) To the south of the Napau Trail, the power plants cannot be seen except from a few high points due to the abrupt change of regional slope. Even when the power plants are visible, they are at distances of one to six miles and thus they would not be significant intrusive features with proper design and construction considerations. In no case are they expected to be seen as a silhouette on the horizon, but instead, they would be a feature in the middle to far distant background. (State Ex. 10, p. E-4).

8) It should be noted that no correction for trees has been incorporated into these perspectives. If trees are included, potential visual intrusions could be further mitigated. (State Ex. 10, p. E-4)

9) Exploratory drill rigs, including a platform, may reach to heights of 149 feet. Rigs may be visible above the teree line in the exploratory area only during the period of exploration. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-32)

10) It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the East Rift Zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, no visible vapors are expected from the cooling towers. (State Ex. 10, p. E-4)

11) A similar terrain analysis should be included in environmental impact assessments for the development of specific sites within a geothermal resource subzones during the subsequent permitting process. (State Ex. 10, p. 36)

12) The preservation of natural beauty and aesthetics could be achieved by well-planned siting, landscaping and well-designed plant architecture. (State Ex. 8, p. 14)

2.4.5 Community Input

1) Various channels and methods of community input are involved in the preliminary as well as future process of geothermal resource development evaluation and actualization, such as the community surveys by the Puna Hui Ohana and by SMS Research, Inc. (State Ex. 8, p. 10)

2) Throughout the process, from the enactment of Act 296, to the Proposal for Designating Geothermal Resources Subzones by the BLNR, public comments and participation have been invited from various interested parties to assist the Department and the Board. (State Ex. 7, p. 1)

3) Public informational meetings were held by the State Department of Land and Natural Resources on May 8, 29, 1984 and July 10, 11, 1984 on the island of Hawaii. (State Ex. 13, p. vi)

4) The first series of meetings were to report the most likely locations of geothermal resources. The second series focused on the identification of impact issues. (State Ex. 7, p. 1)

5) To ensure full public participation, the time, place and purpose of these meetings were announced in newspaper publications, radio announcements and letter invitations. (State Ex. 7, p. 4)

6) The objective of these meetings were to open lines of communication between the public and the Department of land and Natural Resources. (State Ex. 7, p. 1)

7) Other sources of community input utilized in the assessment included the planning processes, goals, objectives and development policies formulated and adopted in community plans that become a part of the County General Plans and the State General Plan, as well as policies brought forth by representatives of people and communities in the State Legislature. (State Ex. 8, p. 11)

2.5 Environmental Impacts

2.5.1 Meteorology

1) The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise.

2) Meteorological monitoring has been included in the 2-year Environmental Baseline Survey of the Kilauea East Rift zone. First year results indicated:

a. The complexity of the land/sea breeze and trade wind interaction is apparent in the diurnal fluctuation of wind direction seen at Site 2 in Kahaualea, and the drainage wind phenomenon seen carrying volcanic fume from Kahaualea over the Pali along the Chain of Craters/Kalapana Road.

b. Both temporal and spatial variability in rainfall is dramatic in the Kilauea East Rift Zone area. This variability can effect the magnitude of TSP material originating from such sources as road and soil dust and spores and pollen from vegetation. (State Ex. 10, pp. 29, 30)

2.5.2 Flora

2.5.2.1 Impact to Native Forest

1) Potential environmental impact on the flora of the Kilauea Upper East Rift Zone, as with other rift zones, was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping which incorporates information on the extent of canopy cover, height of canopy, understory composition and vegetation association type. (State Ex. 10, p. 6)

2) Vegetation information of this type was available for all or portions of each geothermal resource area assessed including all of the Kilauea Upper East Rift Zone. (State Ex. 10, p. 6; State Ex. 2-E)

3) U.S. Fish and Wildlife Service Vegetation Type data were abstracted into a simplified, three category impact sensitivity classification system by the University of Hawaii Environmental Center and was based on the assumption that undisturbed closed canopy forest would be most susceptible to disruption due to geothermal development.

4) The three Categories were defined as follows:

Category 1 -	Exceptional native forest closed canopy, over 90% native cover.

Category 2 -	Mature native forest over 75% native canopy.
Category 2A -	Native scrub or low forest.
Category 3 -	Cleared land; non-native forest; bare ground or lava.

(State Ex. 10, p. 7)

5) Forested areas in the Upper East Rift Zone consist primarily of Category 1, exceptional native forest, closed canopy, with over 90% native cover, Category 2, mature native forest with over 75% native cover, and Category 3, bare lava flows, dated 1968-1973, 1977 and 1983-84. (State Ex. 10, p. 55; State Exhibit 2-E)

6) Disruption of native forest ecosystems is a potential environmental impact resulting from the development of geothermal energy. (State Ex. 10, p. 4)

7) Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas. Once such an invasion begins, native forest is gradually altered and non-native species which initially invaded along relatively narrow corridors spread and multiply. (State Ex. 10, p. 4)

8) Major geothermal development, with an attendant network of roads and construction corridors may be expected to dissect and eventually degrade undisturbed native forest by opening it to invasions by weedy species. (State Ex. 10, p. 4)

9) The northern boundary of the proposed Kilauea Upper East Rift Zone includes approximately 25 percent of Category 1 native forest area located within the Kahaualea section of the Kilauea East Rift Zone. (State Ex. 14, p. 53; State Ex. 2-E)

10) Development of geothermal resources along the Kilauea Upper East Rift Zone will be limited to the proposed subzone area. (State Ex. 14, p. 52)

11) Impact to native forest ecosystems can be mitigated through careful siting facilities, access roads, pipe and powerline corridors so as to avoid damage to biologically valuable forest. (State Ex. 10, p. 4)

12) In order to mitigate this potential impact, encroachment into the native forest area has been minimized by concentrating exploration, development and production activities towards the rift or volcanic flow areas. (State Ex. 13)

2.5.2.2 Impact to Endangered Plant Species

1) Of Hawaii's seven plant species which are formally listed as endangered, only one, the Hawaiian Vetch (*Vicia Menziesii*), was found within the geothermal resource areas, specifically within the Mauna Loa East Rift area. (State Ex. 10, pp. 9, 10)

2) Hawaii has numerous rare plants, over 800 of which have been proposed for listing as endangered. The endemic Hawaiian fern *Adenophorus periens*, known to be present in the Kahaualea section of the Kilauea East Rift Zone, is considered a rare plant, and a "candidate endangered species". (State Ex. 10, p. 9)

3) Currently available information on rare plant species was utilized in the Flora section of the Environmental Analysis. (State Ex. 10, p. 9)

4) Protection of rare plant species will be undertaken on a project-by-project basis where botannical surveys of specific areas considered for development are possible. (State Ex. 10, p. 9)

2.5.3 Fauna

2.5.3.1 Native Birds

1) Forest birds found in the resource areas include the I'iwi, Apapane, Elepaio, and others; however, the specific native forest birds present at a site are not as important as the relative value of the area as native bird habitat in general. (State Ex. 10, p. 10)

2) Most native birds share habitat to some degree and it is this characteristic which permits use of the existence of endangered bird habitat as an index of overall native bird habitat value. (State Ex. 10, p. 10)

3) Federally designated threatened or endangered fauna within the resource areas include seven forest bird species, two seabird species, the Nene, the Hawaiian Hawk (Io) and Crow (Alala), and Hawaii's only resident mammal, the Hawaiian Hoary Bat. (State Ex. 10, p. 10)

4) Hawaii forest birds include the Hawaii Creeper (*Loxops maculatus mana*), Hawaii 'Akepa (*Loxops coccineus coccineus*), Akiapola'au (*Hemignathus wilsoni*), and 'O'u (*Psittirostra psittacea*). All are moderately endangered, with populations in the high 100's or above, except the 'O'u, which is relatively rare and has a much smaller population. Essential habitat common to all four species has

been identified, and intersect all of the East Mauna Loa Rift area, most of Hualalai and Upper Puna, and flanks Kahuku Ranch (USFWS, 1982). (State Ex. 10, p. 10)

5) An Essential Forest Bird Habitat, as described by the Hawaii Forest Bird Recovery Plan does exist in the Kilauea Upper East Rift Zone. (State Ex. 10, p. 10; VCA, Ex. 17, Jacobi Testimony, p. 4, unnumbered).

6) There has been no siting of the endangered 'O'u, a native forest bird, within the geothermal resource subzone. (Cross-examination of Sheila Conant, VCA Ex. 47)

7) No nesting sites for the endangered 'O'u have been found within the Kahaualea area. (CDUA No. HA-3/2/82-1463, BLNR Findings of Fact, 2/25/83, p.4-36)

8) Air quality standards will assure that geothermal emissions will be well below amounts released during eruptions and probably below amounts necessary to cause damage to native flora. (Lamoreux, written testimony, p. 6)

9) Potential impact to native forest birds would result from degradation of the native forest bird habitat from invasion of exotic species along geothermal facility access roads, pipeline and powerline corridors. (State Ex. 10)

10) Development of geothermal resources along the Kilauea Upper East Rift Zone will be limited to the proposed subzone area. (State Ex. 14, p. 52)

11) Impact to native forest ecosystems can be mitigated through careful siting facilities, access roads, pipe and powerline corridors so as to avoid damage to biologically valuable forest. (State Ex. 10, p. 4)

12) In order to mitigate this potential impact, encroachment into the native forest area has been minimized by concentrating exploration, development and production activities towards the rift or volcanic flow areas. (State Ex. 13)

2.5.3.2 Invertebrates

1) Rare invertebrates such as important fruit flies (giant Drosophila spp), tree snails (Partulina spp), and special cave-adapted fauna residing in lava tubes are known to exist in the Mauna Loa East Rift and the Kilauea East Rift Zones. (State Ex. 10, pp. 11, 12)

2) Lava tube ecosystems are dependent on intact penetrating ohia root systems for their moisture supply and are therefore vulnerable to any development which results in forest clearing. (State Ex. 10)

3) Impacts to these species may be largely avoided by avoiding siting facilities in native forest areas. (State Ex. 10)

2.5.4 Surface Water Impacts

1) Almost all geothermal fluids have a total dissolved solids content greater than 1000 ppm. (State Ex. 10, pp. 12. 13)

2) All geothermal fluids will be disposed of by reinjection into the geothermal reservoir. (State Ex. 10, pp. 12, 13)

3) Surface disposal will not be permitted. (State Ex. 10, pp. 12, 13)

4) None of the rift zones considered contain perennial streams. (State Ex. 10, pp. 12, 13)

5) Impact to surface waters is expected to be minimal. (State Ex. 10, pp. 12, 13)

2.5.5 Groundwater Hydrology

1) Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water. (State Ex. 10, p. 13)

2) Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations. (State Ex. 10, p. 13)

3) Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes water is held between the dikes to a height of more than 2,000 feet above sea level. (State Ex. 10, p. 13)

4) The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. (State Ex. 10, p. 13)

5) Basal water uderlies all of the Kilauea East Rift Zone except where dikes occur. (State Ex. 10, p. 13)

6) Ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer and a surface casing is set and cemented through a competent subsurface formation below the basal lens. (State Ex. 10, p. 13)

7) The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the groundwater aquifer. (State Ex. 10, pp. 13, 14)

2.5.6 Air Quality

1) Quantification of pre-development concentrations of naturally occurring emissions in geothermal rift zones is essential in order to assess any future changes in emission concentrations resulting from development of the geothermal resources. (State Ex. 10, p. 26)

2) Quantification has been undertaken by the State Department of Planning and Economic Development in a two-year environmental baseline survey of the Kilauea East Rift Zone (Houck, 1983). Volume 1 of the survey report covers the period between December 1982 and December 1983. A second-year progress report for the period between January 1, 1984 and May 31, 1984 is also available. (State Ex. 10, p. 26)

3) The principal parameters measured in this study include atmospheric concentrations of particulate material, sulfur dioxide gas, hydrogen sulfide gas, chlorine gas, carbon monoxide gas, elemental mercury vaport, radon, elemental and organic content of particulate material, rainwater pH, elemental and anionic content of rainwater, and wind speed and directions. (State Ex. 10, p. 26)

4) Environmental risks are due primarily to atmospheric emissions of noncondensing gases. Hydrogen sulfide, particulate sulfate from the atmospheric oxidation of hydrogen sulfide, benzene, mercury, and radon are considered to be the more significant noncondensing gases from a health standpoint. (State Ex. 10, pp. 15, 16)

5) The first year results of the Environmental Baseline Survey indicate the following ambient conditions:

a. Total Suspended Particulates (TSP) are very low and genrally consist of sea-salt aerosal, road and soil dust, volcanic emissions, diesel exhaust and organic matter.

b. Sulfate particulate matter, and under certain conditions heavy metals contained in particulate matter can be related to volcanic emissions.

c. Current hydrogen sulfide and chlorine gas levels are very low and well below biological impact levels.

d. Occasional short-term hydrogen sulfied episodes at modest concentrations, but of short, less than a day, duration have been observed.

e. Sulfur dioxide concentrations due to volcanic activity can exceed standard values, values typical of urban areas, and human health and plant impact values for days at a time. Higher SO_2 values have been measured in the upper part of the Rift Zone than in the lower portion. In the absence of volcanic impact, SO_2 values are low.

f. Rainwater in Puna and Kau is slilghtly acidic. Acidification is due not only to volcanic emissions but also to long-range transport from sources across the Pacific.

g. All trace elements measureable were found to be below drinking water quality standards.

h. Ambient mercury and radon values were more or less typical of atmospheric values nationwide. However, the impact of volcanic emissions on the atmospheric radon content could be seen by noting the higher values measured at the site closest to the current eruption area in Kahaualea. (State Ex. 10, pp. 28, 30)

6) Igneous-related geothermal reservoirs, such as Kilauea, exhibit small amounts of benezene or none at all. (State Ex. 10, p. 21)

7) The presence of arsenic in geothermal fluids can cause negative health effects including skin cancer if fluids are allowed to contaminate surface waters or ground waters. (State Ex. 10, p. 26)

8) Common practice is to inject residual geothermal fluids back into a geothermal reservoir for disposal, thus isolating spent fluids from drinking water supplies. Injection wells like geothermal wells are drilled past the ground water aquifer and cased so that no leakage to an aquifer can occur. (State Ex. 10, p. 26)

9) The State Department of Health has drafted revisions to its Administrative Rules Chapter 11-59, Ambient Air Quality Standards, and Chapter 11-60, Air Pollution Control, covering geothermal activities. (State Ex. 10, p. 31)

10) Proposed revisions to Chapter 11-59-4 specify ambient air concentrations of carbon monoxide, nitrogen dioxide, suspended particulate matter, ozone, sulfur dioxide, lead and hydrogen sulfide. Under the proposed rule revisions, concentrations of hydrogen sulfide shall not exceed 139 ug/m^3 or 100 ppb. (State Ex. 10, p. 31)

11) Chapter 11-60 is to be amended by adding a new section 11-60-23.1 covering allowable emissions of particulates and hydrogen sulfide for geothermal wells and emissions of hydrogen sulfide only from geothermal power plants. (State Ex. 10, p. 31)

12) Section 11-60-23.1 defines geothermal wells, and sets standards for particulates and hydrogen sulfide. Prior to a well being connected to a power plant, well emissions shall not be in excess of five pounds of particulates, and five pounds of hydrogen sulfide, per one hundred pounds of each respective pollutant in the resource. After a well is connected to the power plant, emissions shall not exceed two pounds per 100 pounds of hydrogen sulfide in the geothermal resource. Permits to construct and operate a geothermal well are required of the well owner or operator. (State Ex. 10, p. 31)

13) The recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the noncondensable gases. (State Ex. 10, p. 30)

14) Use of this system would enable facilities to comply with the proposed State Department of Health air quality standard for geothermal developments since this standard requires 98% of the H_2S present to be removed. (State Ex. 10, p. 30)

15) Given the characteristics of the HGP-A reservoir fluids and the availale emission abatement technology which would be required to comply with proposed State air quality standards, geothermal facility cooling tower emissions should not be toxic and the plume should consist entirely of water vapor. Brine from the plant will be injected back into the geothermal reservoir. (State Ex. 10, p. 30)

16) Abatement of Radon-222 is unnecessary since the level emitted from the power plant is lower than most indoor levels where cement emits radon in most buildings. (State Ex. 10, p. 30)

2.5.7 Noise Impact

1) During the initial phases of geothermal development, persons in the vicinity of a geothermal site may be exposed to noise levels varying from 40 to 120 decibels, depending upon the distance from the well site. (State Ex. 10, p. 33)

2) High noise levels are produced by well drilling, production testing, and well bleeding before connection to the generator. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise. (State Ex. 10, p. 33)

3) The design standard for the HGP-A Wellhead Generator project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. (State Ex. 10, pp. 33, 34)

4) Proposed Hawaii County noise guidelines are 45 decibels at night and 55 decibels by day. It is expected that geothermal facilities will comply with this guideline. (State Ex. 10, p. 34)

2.5.8 Historic and Archaeological Values

1) Development of geothermal facilities by site clearing and facility construction runs the risk of destroying historical and archaeological sites and artifacts. (State Ex. 10, pp. 34, 35)

2) Estimates of likely impacts can be accomplished by (1) plotting the location of known archaeological sites within and nearby proposed subzones, (2) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, and (3) by archaeological reconnaissance surveys on site. (State Ex. 10, p. 34)

3) Each historical or archaeological site located within a proposed geothermal resource subzone or nearby its boundaries was identified and a review of Historic Sites section records made. (State Ex. 10, p. 35)

4) No archaeological sites were noted in the Upper East Rift Zone on the Historic Sites Office maps (State Ex. 10, p. 35)

5) A Literature Search, prepared for the Kahaualea Environmental Impact Statement, addresses sites and activities throughout the ahupuaa of Kahaualea. (State Ex. 10, Appendix C)

6) The Literature Search concludes that given the variety of activities described in various early writings, i.e. canoe building, agriculture, and bird catching, pulu collecting, and descriptions of old trails in various portions of the Ahupuaa of Kahaualeo, some archaeological sites could be expected in the mauka portions of the Ahupuaa. (State Ex. 10, Appendix C, p. C-7)

2.5.9 Scenic and Aesthetic Values

1) Geothermal resource rift zones are located in remote wilderness areas, some of which are heavily forested, development of geothermal facilities can represent a visual intrusion. (State Ex. 10, p. 36)

2) Potential sources of visual intrusion include:

- Clearing forested areas for construction of facilities.

- Temporary 2-3 month presence of drilling rigs.

- o Night lighting of drilling rigs.

- o Continued drilling for new wells, replacement wells, and injections wells (continued presence of drilling rig).

- o Permanent presence of power plant structures with cooling towers (50 to 65 feet in height).

- o Geothermal fluid transmission lines.

- o Electric transmission lines (70 + feet in height).

- o Periodic presence of steam plumes above well heads and power plant cooling towers (under certain climatic conditions, steam plume may rise to 150 to 200 feet above the site).

(State Ex. 10, p. 36)

3) Estimates of visual impact are accomplihsed by preparing an area wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen. A terrain analysis of visual impacts was completed for the preparation of the Kahaualea Environmental Impact Statement. (State Ex. 10, p. 36)

4) The terrain analysis prepared for the Kahaualea EIS, indicated that power plants would be visible from viewpoints along the Napau Crater Trail as well as from many points in the barren lava fields in the area. It was also estimated that one or more power plants may be visible from about 30 percent of the rift zone area north of the Napau Crater Trail. South of the Trail, power plants cannot be seen except from a few high points because of the abrupt change in regional slope. (State Ex. 10, Appendix E, pp. E-3 and E-4)

5) Power plants, if visible, would be at distances of one to six miles and would be part of the middle to far-distant background of an observer. (State Ex. 10, Appendix E, p. E-4)

6) Under certain atmospheric conditions, warm moist air from facility cooling towers may condense to form a small cloud mass. During normal atmospheric conditions, no visible vapors are expected from cooling towers. (State Ex. 10, Appendix E, p. E-4)

2.5.10 Recreational Values

1) Recreational values in remote areas, include hiking, hunting, fishing, and camping. These activities are usually not limited to specific areas and can therefore occur anywhere in a rift zone. (State Ex. 10, p. 37)

2) The impact of geothermal development to remote area recreation uses such as hiking and hunting may result in the loss of segments of some trails and could affect the number of game animals present in the vicinity of the geothermal development. (State Ex. 10, p. 37)

2.6 Compatability of Geothermal Development and potential Related Industries with Present Uses of Surrounding Land and Those Uses Permitted Under the General Plan or Land Use Policies of the County in Which the Area is Located

1) Existing land uses surrounding the proposed Kilauea Upper East Rift Geothermal Subzone include the Hawaii Volcanoes National Park, the grazed area in the vicinity of Ainahou Ranch, the Wao Kele O Puna Natural Area Reserve, and the Volcano and Royal Gardens Subdivisions. Also included are portions of the Kilauea Forest Reserve, Kilauea Military Camp, and Kilauea Golf Course. (State Ex. 10, p. 55)

2) Urban, rural and agricultural state land use districts are administered by individual counties through their general plans, which set forth County objectives and policies for long-range development, and community plans which provide more detailed schemes for implementing general plans. (State Ex. 10, pp. 40, 41)

3) The County of Hawaii Genearl Plan, adopted December 15, 1971, sets forth the following goals and policies for Land Use:

Goals:

1. Designate and allocate land uses in appropriate proportions and in keeping with the social, cultural, and physical environments of the County.
2. Protect and ecourage the intensive utilization of the County's limited prime agricultural lands.
3. Protect and preserve forest, water, natural and scientific reserves and open areas.

Policies:

1. Zone urban-type uses in areas with ease of access to community services and employment centers and with adequate public utilities and facilities.
2. Promote and encourage the rehabilitation and utilization of urban areas which are serviced by basic community facilities and utilities.
3. Allocate apropriate requested zoning in accordance with the existing or projected needs of neighborhood, community, region and County.

4. Establish a "land zoning bank" from which land use zoning may be allocated to specified urban centers and districts.

5. Conduct a review and re-evaluation of the tax structure to assure compatibility with land use goals and policies.

6. Incorporate innovations such as the "zone of mix" into the Zoning Ordinance in order to achieve a housing mix and to permit the more efficient development of lands which have topographic and/or drainage problems. (State Ex. 10, p. 42)

4) The Kilauea East Rift Zone contains land designated as the General Plan as conservation, low density, medium density, resort, open area, orchards, alternate urban expansion, and extensive agriculture zones. (State Ex. 10, p. 43)

5) Geothermal development may in some instances not be strictly compatible with surrounding land uses or the objectives and policies of state and county zoning designations. (State Testimony of Robert T. Chuck, p. 26)

6) Rather than strict compatibility, an acceptable relationship between differing land uses and County land use planning objectives and policies should be sought. An acceptable relationship is one in which mitigation of impacts can be achieved; one in which a buffer can be provided; one which the need for development of the geothermal resources is balanced against the mitigated impacts. (State Testimony of Robert T. Chuck, p. 26)

7) In addressing land use compatibility, the following assumptions were made:

- o Ambient air quality will not be affected since it is expected that current abatement technology will be fully utilized in compliance with proposed State Department of Health air quality standards for geothermal development.

- o Proposed County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with. It is also assumed that the County of Maui will adopt similar noise guidelines in reference to geothermal activities.

- o Geothermal facility siting will be adjusted to avoid endangered plants and significant archaeological or historical sites.

- o Visual impacts will be minimized by adjusting the location of the site, the alignment of structures so as to present the smallest possible aspect and by blending structures with surroundings by painting appropriately and by use of non-reflective, light absorbent materials and textures and by shielding facilities from view by locating behind a puu, or hill, or by placement in a forested area.

- o Impacts will be further minimized by use of buffer zones surrounding geothermal facilitieis. (State Testimony of Robert T. Chuck, page 26; State Ex. 10, p. 50)

8) Given these assumptions, it was concluded that compatibility with existing land uses and zoning can be achieved, and a subzone designated where clearly there exists a potential for production, prospect for utilization, mitigation of geologic hazards, and potential economic benefit to the people of the state. (State Testimony of Robert T. Chuck, pp. 26, 27)

2.7 Potential Economic Benefits to be Derived from Geothermal Development and Potential Related Industries

2.7.1 Economic Need for Indigenous Supply of Electrical Energy

1) The State of Hawaii depends upon petroleum suplies for 91.4 percent of all the energy consumed in the State. The oil that Hawaii imports costs the State about $1.5 billion per year in funds which flow out of the State for this purchase. As a consequence of the high cost of imported fuel, electricity rates in Hawaii are among the highest in the nation. The Department of Planning and Economic Development believes that geothermal energy is the largest, near-term baseload electric energy potential for Hawaii. Large scale development of the geothermal resources on the Big Island is essential to the attainment of the State and County of Hawaii objectives of energy self-sufficiency. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-43)

2) About 60 percent of the total energy produced on the Big Island is generated from fossil fuels such as industrial and diesel oils. Due to the uncertainties of the price and supply of fuel oil, HELCO is seeking to ultimately meet electrical system demands solely from renewable energy sources such as geoehtermal. In order to encourage the development of geothermal resource in Puna by private developers, HELCO issued a Request for Proposal (RFP) regarding the development of the resource for electric generation. Three private organizations responded to HELCO's RFP including True/Mid-Pacific. These organizations are presently preparing to respond to the second phase of the RFP which requires them to prove that they have a firm source of steam suitable for use in generating electricity. The first phase was the qualification phase. HELCO will select a qualified developer who can develop the resource and supply reliable electrical power at the most favorable terms to HELCO and ratepayers. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-43)

3) HELCO's Forecast Planning Committee is presently looking at a 2 percent per year load growth for the Big Island over the next 20 years. Excess electrical energy produced by geothermal energy could

be exported to Oahu and the other islands if the deep-water cable that is currently under study can be installed to electrically connect the islands. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-43)

2.7.2 Potential Jobs from Geothermal Development

1) The Kilauea Upper East Rift geothermal subzone is presently unused as an economic entity as there are neither residents nor any economic activities on the parcel. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-42)

2) From 1960 to 1980, Puna's population growth rate more than doubled to a 234 percent increase. A disproportionately large part of the population growth in Puna occurred in the age bracket where people are most likely to be in the labor market from ages 22 through 44. As a result, the labor force on the Big Island has been growing faster than work opportunities there. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-44)

3) The economic activity which could be genrated by True/Mid-Pacific's proposed 250 MW project would build up gradually during the initial years of exploratory and development drilling. The addition of 50 direct jobs during the road construction and exploration drilling phase of the initial operations will make a modest contribution to the employment requirements of the existing working population on the Big Island. As the project moves into an exploration and development phase, 200 to 300 construction jobs would be created to building the generating plants. Many of the construction skills necessary for the project can be drawn from existing unemployed or underemployed persons on the Big Island. The period of employment from resource location and quantification to market determination will take several years to mature. The greater employment opportunity at Kahaualea may not be available until the end of this decade. Except for a small supervisory staff, it is the long-range objective of the developer to hire local residents (contracting firms) as much as possible. Campbell witness Capuano testified the exploratory drilling phase would employ only 15 people. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-45)

4) A 20 to 30 MW geothermal power plant will have some economic impact on a State-wide and County-wide basis, but the impact would probably not be significant. Based upon the data available, the direct wages to the 25 direct project employees will be about $560,000 per year. This direct income will stimulate a multiplier effect totalling an estimated $1.3 million. Additionally, an estimated 57 additional jobs will be created. (State Ex. 9, p. vii)

2.7.3 Public Revenue from Geothermal Development

1) Based on a 20-30 MW scenario, the selected sources of public revenue analyzed will not yield a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, only after a more complete analysis of the pubic revenue and public or community resource cost of a specific development will it be known whether the public revenues will outweigh the public costs. (State Ex. 9, p. vii)

2) Various sources of public revenue may result from the existence of a geothermal plant, including property tax, fuel tax, general excise tax, corporate income tax, personal income tax, and possibly royalty income. (State Ex. 9, p. 4)

2.7.4 Impacts on Community Infrastructure

The impact of the assumed 25 additional households from a 20-30 MW development to the community would be primarily in the housing market, assuming that all the assumed 25 workers needed by a 20-30 MW plant come from outside the County. Realistically, only a portion will be "imported" into the County. Thus the impact on housing is not expected to be as great. Other community resources will not be affected in a significant manner. (State Ex. 9, p. vii)

Each of the assumed 25 households from a 20-30 MW development will require housing units. At current market prices, these households will probably rent or lease rather than purchase. With a tight housing market, the additional households will place increasing upward pressure on housing prices. This will be especially true in the rental market where the demand is expected to be the greatest. (State Ex. 9, p. 6)

As a Statewide average cost per pupil of $2,700 in 1982, the assumed 25 additional households from a 20-30 MW development would possibly increase educational expenditures by approximately $62,100 in 1982 dollar terms. This figure will cover the cost of an additional teacher that will probably be required for the estimated 23 school-age children. (State Ex. 9, p. 6)

Assuming a ratio of 2 sworn police offiers per 1,000 resident population, no additional police offiers will be required for the assumed additional 78 residents from a 20-30 MW development. (State Ex. 9, p. 7)

The assumed additional 78 residents from a 20-30 MW development within a community would not require additional firemen, assuming a ration of 2.2 firemen per 1,000 population. (State Ex. 9, p. 7)

2.7.5 Potential Industries Related to Geothermal Development

It was assumed that a 20-30 MW plant would be used solely for the production of electricity for local consumption. However, direct use application of geothermal power in "spa" facilities, agriculture, aquaculture, food processing, and other uses, in addition to the use of electricity may be feasible. Larger geothermal developments may also support alternate industries such as manganese nodule processing and the transmission of "excess" electricity to Oahu via an undersea transmission cable. However, it must be determined during subsequent permitting processes whether these conditional uses are appropriate in the Conservation district in which the Kilauea Upper East Rift Geothermal Subzone is situated. (State Ex. 9, p. 10)

2.8 Compatability of Geothermal Development and Potential Related Industries with the Uses Permitted under Sections 183-41 and 205-2, Hawaii Revised Statutes, Where the Area Falls Within a Conservation District

1) Conservation Districts include areas necessary for protecting watershed and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept. (State Testimony of Robert T. Chuck, p. 28)

2) Conservation means a practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural and scenic resources attendant to land including territorial waters within the State, to ensure optimum long-term benefits for the inhabitants of the State. (State Testimony of Robert T. Chuck, p. 28)

3) Of the four land use districts, the Conservation District is the only one administered by the State of Hawaii. Individual counties administer urban, rural and agricultural lands. (State Ex. 10, p. 39)

4) Chapter 183-41, HRS, established Conservation Districts and enabled the State Department of Land and Natural Resources to promulgate regulations to implement the statute. Implementation was accomplished under the Department's Administrative Rule, Title 13, Chapter 2. Under this rule, the Conservation District is further subdivided into five subzones: Protective (P), Limited (L), Resource (R), General (G) and Special Subzones (SS). (State Ex. 10, p. 39)

5) The Protective Subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other deisngated unique areas. The Limited Subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the Resource Subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General Subzones are open space areas where specific conservation uses may not be defined, but where urban use would be premature. Special Subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area. (State Ex. 10, p. 39)

6) In accordance with the Administrative Rules of the Department of Land and Natural Resources, State of Hawaii §13-2-11, 12, 13, and 14 certain uses are permitted within each of the Conservation District subzones. The following uses are permitted in the Protective Subzones:

(1) Research, recreational, and educational use which require no physical facilities;

(2) Establishment and operation of marine, plant, and wildlife, sanctuaries and refuges, wilderness and scenic areas, including habitat improvements;

(3) Restoration or operation of significant historic and archaeological sites listed on the national or state register;

(4) Maintenance and protection of desired vegetation, including removal of dead, deteriorated and noxious plants;

(5) Programs for control of animal, plant, and marine population, to include fishing and hunting;

(6) Monitoring, observing, and measuring natural resources;

(7) Occasional use; and

(8) Governmental use not enumerated herein where public benefit outweighs any impact on the conservation district.

The following uses are permitted in the Limited Subzone:

(1) All permitted uses stated in the (P) subzone;

(2) Emergency warning systems or emergency telephone systems;

(3) Flood, erosion, or siltation control projects; and

(4) Growing and harvesting of forest products.

The following uses are permitted in the Resources Subzone:

(1) All permitted uses stated in the (P) and (L) subzone;

(2) Aquaculture;

(3) Artificial reefs; and

(4) Commercial fishing operations.

The following uses are permitted in the General Subzone:

(1) All permitted uses as stated in the (P), (R), and (L) subzones; and

(2) Development of water collection, pumping, storage, control, and transmission.

(State Ex. 10, p. 40)

7) The Kahaualea section of the Upper East Rift Zone is zoned Conservation, Limited Subzone. The objective of the Limited Subzone as stated in the Department's Administrative Rule, Title 13, Chapter 2, is to limit uses where natural conditions, such as volcanic acrtivity, suggest constraints on human activities. (State Testimony of Robert T. Chuck, p. 39)

8) Development of geothermal facilities would entail intermittent, limited use of the Conservation District by persons operating a geothermal facility. Evacuation of a limited number of individuals from an area in the event of volcanic activity can be accomplished quickly, thus conditional use of the Limited Subzone could be allowed. (State Testimony of Robert T. Chuck, p. 40)

9) In each of the Conservation District subzones, Protective, Limited, Resource and General the use of the area for "monitoring, observing, and measuring natural resources" is permitted. In this respect, exploration of geothermal resources can be allowed in a conservation district.

10) The Board of Land and Natural Resources granted the Estate of James Campbell permission to conduct baseline and exploratory activities for the purpose of measuring, monitoring, and observing potential geothermal resources within the area of Kahaualea

on February 25, 1983, as these are clearly permitted uses within this Limited subzone of conservation classified lands. DLNR's Administrative Rules and Regulations specifically allow as a permitted use in the Limited subzone the following: monitoring, observing, and measuring natural resources. (DLNR 13-2-11(c)(6)) (CDUA No. HA-3/2/82-1463, Findings of Fact, Conclusions of Law, Decision and Order, February 23, 1983, p. 9-1)

11) The development of geothermal resources can lead to widespread public benefit. The use of lands within a conservation district in which "governmental use not enumerated herein where public benefit outweights any impact on the conservation district" is permitted. In managing the uses of conservation lands, careful analysis of the proposed use is required and when the benefits of the proposed use are determined to be greater than any impact on the land, the use can be permitted. (State Testimony of Robert T. Chuck, p. 40)

12) Public benefit from geothermal resources to be developed in the Kiluaea Upper East Rift Zone has been established and mitigation of potential impacts can be accomplished. As such, an acceptable balance between geothermal development and the objectives of the Conservation District has been established.

2.9 Objectives, Policies and Guidelines Set Forth in Part I of Chapter 205A, HRS

1) Chapter 205A, Coast Zone Management was reviewed for applicability as provided by Act 296, HRS 1983, and a determination was made that the objectives, policies and guideline is not applicable to the designation of geothermal resource subzones at the Kilauea Upper East Rift, Island of Hawaii.

2.10 Provisions of Chapter 226, HRS

1) Chapter 226 Hawaii State Planning Act was reviewed for applicability and a determination was made that substantial provisions of the Chapter applies to the designation of geothermal resource subzone at the Kilauea Upper East Rift, Island of Hawaii.

2) The Hawaii State Planning Act provides the achievement of the following objectives in planning for the State's energy facility systems:

a. Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people.

b. Increased energy self-sufficiency. (State Ex. 14, p. 23)

3) Policies to achieve the energy objectives are cited:

a. Accelerate research development and use of new energy sources.

b. Provide adequate, reasonably priced, and dependable power to accommodate demand.

c. Ensure a sufficient supply of energy to enable power systems to support the demands of growth.

d. Promote the use of new energy sources. (State Ex. 14, p. 23)

4) Chapter 226 also establishes an overall priority direction to address areas of statewide concern. The priority action for energy use and development include "encourage the development of alternate energy sources." (State Ex. 14, p. 23)

5) The Hawaii State Planning Act also provides for the formulation of Functional Plans in twelve functional areas of services provided by the State government. One such area specified is in the functional area of energy. The Act provides that the functional plan shall contain objectives to be achieved and policies to be pursued in the primary field of activity and such policies shall address major programs and the location of major facilities, and shall also contain implementtion priorities and actions which may include, but not be limited to, programs, maps, regulatory measures, standards, and interagency coordination provisions.

The following implementing actions relating to geothermal energy are excerpted from the State Energy Functional Plan.

ALTERNATE ENERGY RESOURCE DEVELOPMENT

"B. OBJECTIVE: Accelerate the Transition to an Indigenous Renewable Energy Economy by Facilitating Private Sector Activities to Explore Supply Options and Achieve Local Commercialization and Application of Appropriate Alternate Energy Technologies.

"Hawaii's near-total dependence on imported petroleum, spiraling oil prices, the net outflow of dollars for oil payments, and the political unrest of major oil-producing nations threaten local economic stability and the ability to serve energy needs over time. Support and assistance for private sector activities to develop local energy resources will reduce dependence on the world oil market, improve the State's balance of payments, and thus promote economic development, and increase the number and diversity of employment opportunities.

"B(1). POLICY: Investigte and alleviate non-technical (legal/institutional/economic/financial) barriers to alternate energy resource development.

"B(1)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Support continued implementation of the State Geothermal Commercialization Program to address and mitigate legal and institutional concerns.

"B(2). POLICY: Facilitate research, development and demonstration activities designed to resolve remaining technical barriers to alternate energy technologies in order to expedite local commercialization.

"B(2)(a). IMPLEMENTING ACTION: Continue statewide alternate energy resource assessment studies as appropriate to supplement private sector investigations.

"B(2)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Continue geothermal research activities as appropriate to support commercialization efforts."
(State Ex. 14, pp. 24-26)

2.11 Consideration and Examination of Factors for Recommending Subzone Designation

1) In enacting Act 296, the Legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. (Act 296, SLH 1983, Section 1)

2) Pursuant to Act 296, the BLNR compared all areas showing geothermal potential within each county and proposed geothermal resource subzones, based on a finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection b of Act 296. (Act 296, Subsection D)

3) The Technical Committee did conduct a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. (State Ex. 14, p. 63)

4) Twenty separate potential geothermal resource areas were identified and studied. Of these, seven areas were identified and mapped as having high temperature geothermal resources of 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9840 feet. Five areas are located on the island of Hawaii and two on Maui. Five other areas in the State were identified as having low temperature geothermal resources of less than 125 degree celsius. (State Ex. 14, p. 63)

5) Examination of the factors set forth in subsection b of Act 296 indicated that several impacts may result from the exploration, development, and production of geothermal resources for electrical power generation; however, these impacts can be mitigated. All of these factors have been cumulatively examined and it has been determined that the Kilauea Upper East Rift Geothermal Resource Subzone can provide an acceptable balance among these factors as required by Act 296, SLH 1983. (State Ex. 14, p. 63)

6) The Kilauea Upper East Rift Zone has been found to have the following desirable elements for the exploration, development and production of geothermal resource energy. (State Ex. 14, p. 64)

a. The Kilauea Upper East Rift Zone has potential for developing geothermal resources. (State Ex. 14, p. 64)

b. There is interest in the exploration, development and production of geothermal resource energy in the Kilauea Upper East Rift Zone. (State Ex. 14, p. 64)

c. There is a commitment towards geothermal resource energy as a viable alternate energy source for Hawaii. (State Ex. 14, p. 64)

d. Advanced technology in geothermal resource development, such as emission control systems, noise control systems, well and power plant designs, and safety provisions from lava flows, will reduce the concerns for public health and safety. (State Ex. 14, p. 64)

e. Potential environmental impacts have been fully investigated and it has been determined that these impacts can be mitigated to accerptable levels. (State Ex. 14, p. 64)

7) After having considered and examined all factors, the Board of Land and Natural Resources hereby determines that the Kilauea Upper East Rift Geothermal Resource Subzone be designated as a geothermal resource subzone.

B. CONCLUSIONS OF LAW

1) The Board of Land and Natural Resources has the authority, pursuant to Act 296, SLH 1983, and Act 151, SLH 1984, and, also, its Administrative Rules, Title 13, Chapter 184, to designate the Kilauea Upper East Rift Zone as a geothermal resource subzone.

2) In its assessment of the Kilauea Upper East Rift Zone as a potential geothermal resource subzone, the Board of Land and Natural Resources has fully examined and considered the following factors:

a. The area's potential for the production of geothermal energy;
b. The prospects for the utilization of geothermal energy in the area;
c. The geologic hazards that potential geothermal projects would encounter;
d. Social and environmental impacts;
e. The compatibility of geothermal development and potential related industries with present use of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;
f. The potential economic benefits to be derived from geothermal development and potential related industries;
g. The compatibility of geothermal development potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district; and
h. The objectives, policies and guidelines set forth in Part I of Chapter 205A, and the provisions of Chapter 226, HRS, the Hawaii State Planning Act, and also, the Hawaii State Energy Functional Plan.

3) The designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone does not per se allow use of the area for geothermal exploration, development, and production of electrical energy; use of the Kilauea Upper East Rift Zone for geothermal exploration, development and production will be allowed only upon issuance of subsequent permits by the appropriate State or County government agencies on a case-by-case basis.

4) The Kilauea Upper East Rift Zone proposed for designation as a geothermal resource subzone is comprised of lands designated "conservation district" by the State Land Use Commission.

5) The Board of Land and Natural Resources, State of Hawaii, has the authority, pursuant to Chapter 205, HRS, and Chapters 171 and 183, HRS, and its Administrative Rules, Title 13, Chapter 2, to act upon and approve Conservation District Use Application Permits.

6) Geothermal use may be allowed within the Conservation District under Title 13, Chapter 2, Administrative Rules of the Department of Land and Natural Resources.

7) The Division of Water and Land Development of the Department of Land and Natural Resources, as the agency proposing the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone has the burden of presenting a prima facie case in support of the proposed designation.

8) A prima facie case having been established by the Division of Water and Land Development, the burden of proof then is upon those parties initiating the contested case proceedings to prove, by a preponderance of the evidence:

a. that the Kilauea Upper East Rift Zone should not be designated as a geothermal resource subzone, or

b. that the evidence and record before the Board of Land and Natural Resources does not support the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone.

9) The provisions of Act 296, SLH 1983, Act 151, SLH 1984, and Administrative Rules, Title 13, Chapter 184 of the Department of Land and Natural Resources have been fully complied with in the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone.

C. DECISION

Based on the Findings of Fact and Conclusions of Law stated herein, IT IS THE DECISION of the Board of Land and Natural Resources, as follows:

1) There exists a future need for geothermal energy as an alternate source of energy on the Island of Hawaii and throughout the State of Hawaii.

2) Kilauea Upper East Rift Zone has high potential for geothermal energy resource development.

3) There exists substantial private developer interest in the exploration of geothermal resource energy in the Kilauea Upper East Rift Zone.

4) The evidence and record before the Board of Land and Natural Resources supports, by a preponderance of the evidence, the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone.

5) Those parties and intervenors participating in the contested case hearing as opponents to the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone have failed to prove, by a preponderance of the evidence, that the Kilauea Upper East Rift Zone should not be designated as a geothermal resource subzone.

6) Those parties and individuals participating in the contested case hearing as opponents to the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone have failed to prove, by a preponderance of the evidence, that the evidence and record before the Board of Land and Natural Resources does not support the designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone.

7) The Board of Land and Natural Resources hereby approves and designates that portion of the Kilauea Upper East Rift Zone, containing an area of 5,300 acres, more or less, described herein and more particularly delineated on the maps marked "Figure 1" and "Figure 2", attached hereto and made parts hereof, as a geothermal resource subzone.

8) In its designation of the Kilauea Upper East Rift Zone as a geothermal resource subzone, the Board of Land and Natural Resources has fully considered and balanced the development and exploration of Hawaii's geothermal resources with the interests in preserving Hawaii's unique social and natural environments.

D. ORDER OF BOARD OF LAND AND NATURAL RESOURCES

The herein Findings of Fact, Conclusions of Law and Decision of the Board of Land and Natural Resources are hereby APPROVED AND SO ORDERED.

DATED: Honolulu, Hawaii, ______________________________.

BOARD OF LAND
AND NATURAL RESOURCES

SUSUMU ONO
Chairperson and Member

ROLAND H. HIGASHI
Member

THOMAS S. YAGI
Member

MOSES W. KEALOHA
Member-at-Large

APPROVED AS TO FORM:

WILLIAM M. TAM
Deputy Attorney General
State of Hawaii
Attorney for BOARD OF LAND
AND NATURAL RESOURCES

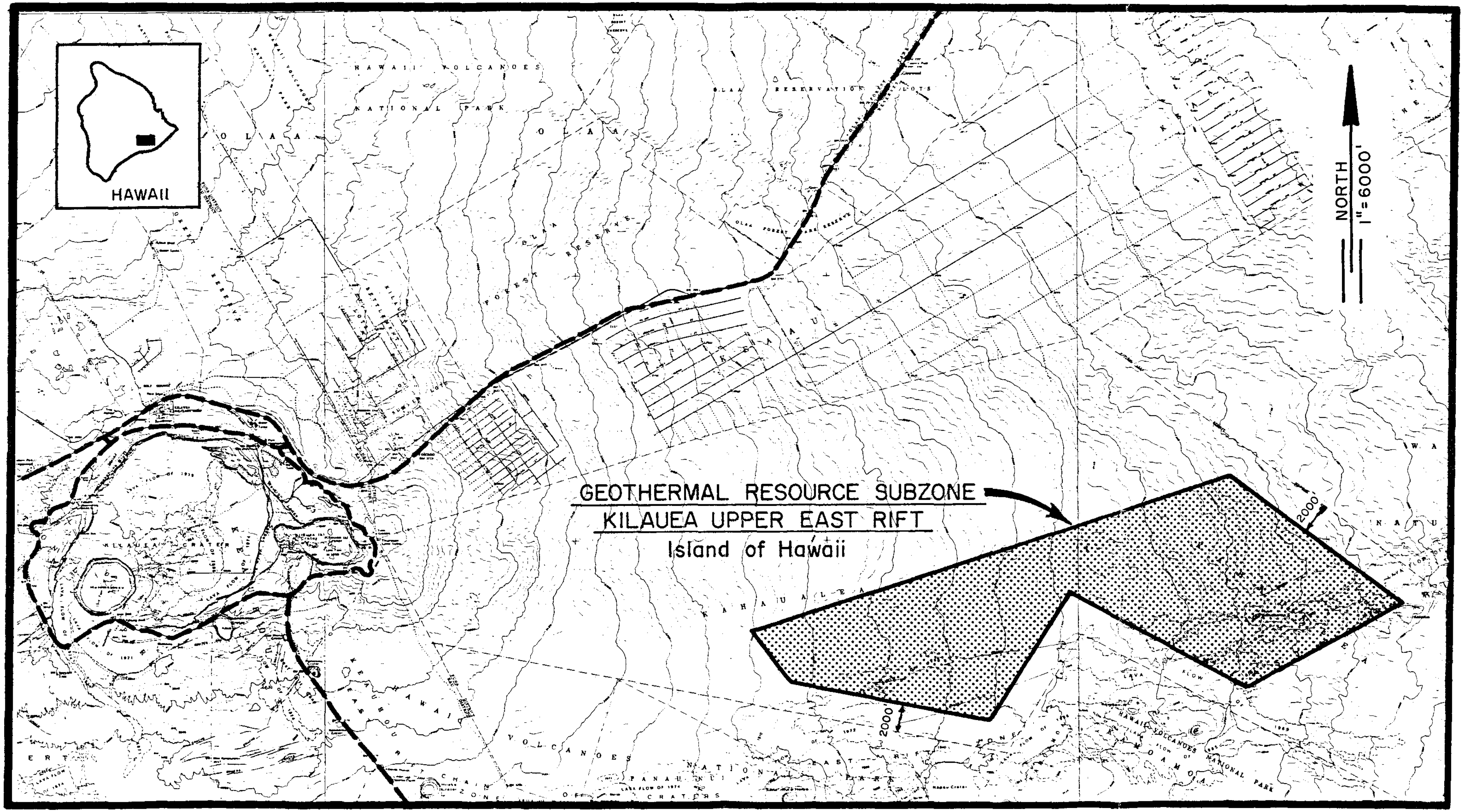
GEOTHERMAL RESOURCE SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii
HAWAII
NORTH
1" = 6000'
2000'
2000'
HAWAII VOLCANOES
NATIONAL PARK
OLAA RESERVATION LOTS
OLAA
OLAA FOREST RESERVE
KILAUEA CRATER
VOLCANOES
NATIONAL PARK
CHAIN OF CRATERS
KAHAUALEA

Figure 1.

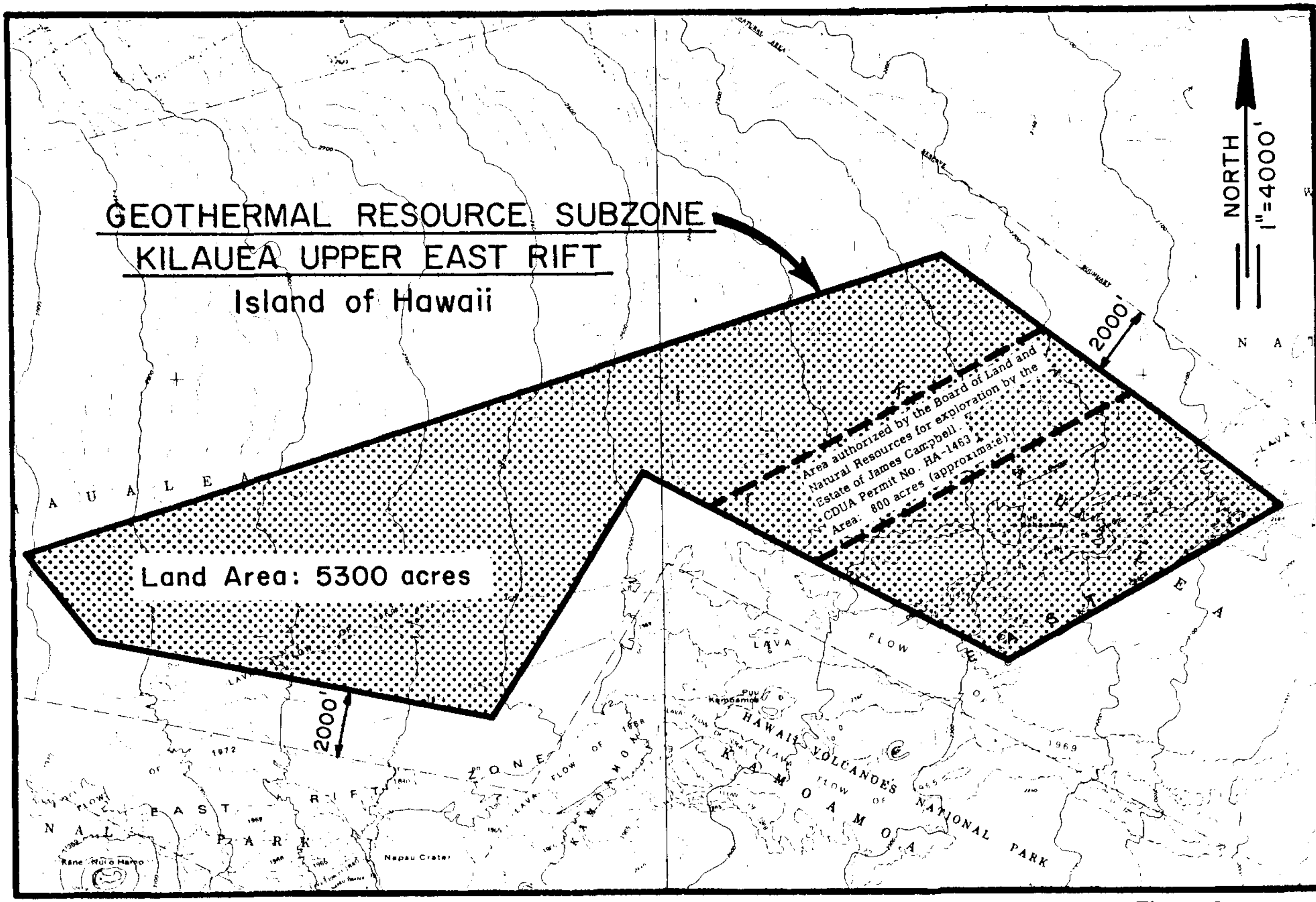
GEOTHERMAL RESOURCE SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii
NORTH
1"=4000'
2000'
Area authorized by the Board of Land and
Natural Resources for exploration by the
Estate of James Campbell.
CDUA Permit No. HA-1463
Area: 800 acres (approximate)
Land Area: 5300 acres
2000'
EAST RIFT ZONE
HAWAII VOLCANOES NATIONAL PARK
Napau Crater
Kane Nui o Hamo
1972
1969

Figure 2.

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Proposed Findings of Fact, Conclusions of Law and Decision of the Division of Water and Land Development, Department of Land and Natural Resources, was served by mail, postage prepaid upon the following parties:

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  - Volcano Community Association c/o Russell Kokubun
  - Lehua Lopez
  - Eva Lee
  - Louis Whiteaker
  - Chiu Leong
  - Virginia B. MacDonald
  - Debra Hopson
  - Donald King
  - Marguerite King
  - Ann Markham
  - Mike Markham
  - Beverly MacCallum
  - Russell Apple
  - Matt Luera
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DATED: Honolulu, Hawaii, December 24, 1984.

Edwin P. Watson

EDWIN P. WATSON
Deputy Attorney General
State of Hawaii
Attorney for DIVISION OF
WATER & LAND DEVELOPMENT,
DEPARTMENT OF LAND & NATURAL
RESOURCES

#12

GEOLOGIC HAZARDS IMPACT ANALYSIS OF POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-107

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

GEOLOGIC HAZARDS IMPACT ANALYSIS OF POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-107

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
September 1984

GEORGE R. ARIYOSHI
Governor

BOARD OF LAND AND NATURAL RESOURCES

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Board of Land and Natural Resources

EDGAR A. HAMASU, Deputy to the Chairperson

ROBERT T. CHUCK, Manager-Chief Engineer
Division of Water and Land Development

PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which addresses each of the subzone factors. This report analyzes the major geologic hazards and their resultant effects within potential geothermal areas. Effects include risks to people and property. Available hazard mitigation techniques will also be described.

This report was prepared by Joseph Kubacki, Energy Specialist, in collaboration with Dr. George Walker, Volcanologist with the Hawaii Institute of Geophysics, and under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development, Department of Land and Natural Resources.

CONTENTS

FIGURES

SUMMARY

The same volcanic activity which provides the source of geothermal heat may also create a hazard to people and property. Volcanic hazards include lava flows, pyroclastic fallout, ground deformation, cracking, and subsidence. With proper evacuation planning, lava flows should not be a great danger to people because of their usually slow speed and somewhat predictable paths; however, substantial property damage is a possibility. The table below summarizes past eruptive activity.

Historic Eruptions Within Geothermal Resource Areas

Location	Number of Eruptions Since 1750	Average Area (km^2)
Kilauea Upper East Rift*	21	6
Kilauea Lower East Rift*	5	11
Kilauea Southwest Rift	5	7
Mauna Loa Northeast Rift	7	37
Mauna Loa Southwest Rift	7	34
Hualalai	1	46
Haleakala Southwest Rift	1	6
Haleakala East Rift	0	--

A significant phenomenon is unique to Kilauea: the southern flanks of its rift zones are much more prone to be covered by lava flows than are the north flanks due to topography. This is clearly depicted by the chronological maps in figure 9 and by the graph in figure 10.

*An imaginary line extending approximately north of Kalapana distinguishes the lower and upper east rift zone. Caldera eruptions were not considered.

Earthquakes hazards include ground shaking, cracking, and subsidence. Several tectonic earthquakes above magnitude 6 have been reported on the island of Hawaii; particularly in the coastal and saddle areas. Less powerful, volcanic earthquake swarms commonly occur in rift zone areas.

Geothermal developments near coastal areas should consider the possibility of damage from tsunami and ground subsidence.

Several mitigation methods are described which may reduce the risk from geologic hazards. These methods include strategic siting, special construction designs and fortifications, evacuation planning, decentralization of power plants, and giving development investors a clear economic incentive to utilize mitigation methods by having them assume a major portion of the associated risks of loss.

In the past, several attempts have been made to restrict the flow of lava in Hawaii, Italy, and Iceland. These examples are provided to illustrate the effectiveness of the technology used and the costs involved. In those situations, governmental authorities spent large amounts of money, sometimes millions of dollars, in efforts to protect communities threatened by lava flows.

The past history and nature of geologic hazards can provide a valid guide to the probable course of future activity; although it is not possible to detail the specific time and location of such activity.

GEOLOGIC HAZARDS IN HAWAII; THEIR DESCRIPTION AND EFFECT

LAVA FLOWS

Lava flows are generated in most volcanic eruptions in Hawaii and can cover extensive areas extending out to more than 10 km from the source; be they from a vent or a long linear fissure or crack. Lava tends to flow freely in a fairly predictable course determined by ground slope. However, ridges built by cooling lava on the sides of a flow may create channels and divert lava from the steepest slope. Flows from earlier phases of an eruption can quickly change the topography and expected course of the flow. In a somewhat similar manner, other natural and man-made obstacles can divert lava flows.

Most lava flows are thin, about 1 meter in near vent areas increasing commonly to about 5 meters in its distal part; although some individual flows (e.g. Pu'u O) have been significantly thicker. Structures more than 5 meters high are not immune from burial by lava. There is a strong tendency for many lava flow units to be generated during a single eruption. These flows will superpose upon one another, particularly near the vent where accumulations over 10 meters thick may be constructed by accretion of many individually thin layers.

Lava flows vary in their flow behavior. Thick distal aa flows tend to bulldoze, crush, bury, and burn any surface structures in their path. The more fluid, newly erupted, proximal (near-vent) lava tends to flow around obstacles. A fluid flow could enter buildings and may not cause much structural damage beyond igniting flammable materials and softening and distorting some of the metalwork. In principle, fluid pahoehoe lava could subsequently be removed and the building reoccupied. In principle this would also apply to flows covering protective well cellars and thin pahoehoe flows surrounding transmission piping (see mitigation below).

Removal of cooled lava would be feasible if the flows were sufficiently thin and friable, and if the eruption was not lengthy. Using Kilauea as an example, since 1800, the average duration of an eruption has been about 60 days, with many lasting only one day and some, such as the Mauna Ulu and the current Pu'u O eruptions, lasting years.

Since the crust tends to insulate underlying lava, cooling time for lava increases exponentially with the thickness of the flow. It would take about 200 days for 1 meter (1000 days for 4 meters) of lava to cool to 200°C (extrapolated from Peck, 1974). However, cooling time can be significantly reduced if great amounts of water are applied to a cooling flow area. (See section on lava cooling effort at Heimaey Island, Iceland.)

Thus, recovery from a deep or long enduring flow could take many months. Mitigation techniques may significantly reduce risk from flows. A long recovery time would not be acceptable to a damaged electric utility power plant unless sufficient reserve capacity were available.

Past volcanic activity can suggest future activity, however it is not possible to detail the specific time and place of future eruptions. Summit swelling and increasing swarms of volcanic earthquakes can warn of impending eruptions.

PYROCLASTIC FALLOUT

Explosive eruption fountains may eject rock fragments of many sizes and types. The weight and depth of fallout can be appreciable as far as even 500 or 1000 m away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones that may be tens of meters high. Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent. Figure 1 shows a pumice blanket originating from Kilauea Iki vent. Cones tend to be higher and fallout more extensive on older volcanoes, such as Haleakala than on Mauna Loa or Kilauea; some cones on Haleakala exceed 100 meters high.

The probability of an eruption being powerfully explosive (with resultant increased debris) increases as the coast is approached and is near 100% for a vent within about 1 km of the coast. Steam generated by magma from the near-surface groundwater promotes such explosiveness. An example of potential damage from pyroclastic fallout is given by the 1960 Kapoho eruption where some buildings were destroyed because of the weight of cinder and ash upon their roofs (Macdonald, 1962). Other dangers from fallout include lung irritation, poor visibility, anxiety or panic, blockage of escape routes, and severe cleanup problems.

GROUND CRACKS

Cracks, which may open as much as several feet, can be the surface expression of dikes that fail to reach the surface. These cracks can produce a surface graben several meters wide and deep in which the ground is let down between two parallel cracks. This type of cracking related to magma movements is concentrated in volcanic rift zones which are clearly defined and narrow features (see figure 2). Cracks could also open outside a rift zone; not enough information is available to access the probability, but it decreases rapidly as the distance from the rift zone increases.

Ground cracking can also be associated with earthquakes, resulting from tectonic activity. Their formation is often accompanied by a relative vertical or lateral displacement of the ground on either side. Tectonic ground cracking is usually localized in definable zones; e.g. the Hilina and Koae fault systems at Kilauea (see figure 3).

Ground cracking across a geothermal plant could cause a suspension of operation, depending on the extent and location of damages.

Pipes carrying steam between the wells and plant are likely to remain undamaged by moderate ground cracking, since they are designed with expansion joints at regular intervals.

Ground cracking close to a well bore might open up an alternate path for the steam and cause its loss from the well. It is unlikely for a crack to intercept a well bore due to the vertical pitch of most cracks.

GROUND SUBSIDENCE

On the mainland, subsidence due to contraction of clay or sand formations may result from the withdrawal of geothermal fluids in those formations. In Hawaii, subsidence from geothermal fluid withdrawal is not likely to be problem; since the islands are generally composed of dense, yet porous, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which usually occurs on or about active rift zones, e.g. Kilauea.

Small to large grabens may result with the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks, e.g. 1960 Kapoho graben (see section on ground cracks).

Subsidence and cracking may also be associated with tectonic earthquakes, e.g. subsiding slump blocks in Hilina fault system at Kilauea (figure 3).

Collapsing pit craters and lava tubes can result in very severe localized subsidence. Pit craters usually occur within a summit or upper rift zone of a volcano. Figure 4 explains their formation which can result in subsidence up to hundreds of feet. Fragile, near-surface lava tubes (usually found in pahoehoe flows) are subject to collapse from heavy surface activity. A geologic site survey could reveal these hazards.

Aside from the immediate effects subsidence may have on the foundation and contents of a power plant; subsidence also increases the hazards from lava flows since flows usually seek lower areas.

EARTHQUAKES

Most earthquakes in Hawaii are volcanic; resulting from near-surface magma movements. They are small in magnitude and usually cause little direct damage. Larger earthquakes tend to be tectonic, generally resulting from the movement of large rock bodies.

The largest Hawaiian earthquake occurred on the island of Hawaii in 1868, having a magnitude of 7.5.

Major earthquake shaking can easily damage buildings; especially those poorly constructed. Indirect damage may be caused by the smaller but more frequent volcanic earthquakes; e.g. collapse of lava tubes, landslides, and compaction (Mullineaux and Peterson, 1974). It is recommended that power plants be constructed to withstand shaking from a 7.5 magnitude earthquake (Stearns).

TSUNAMI

Tsunamis are large sea waves usually generated by movement of large submarine rock masses although some are caused by volcanic eruptions. These devastating waves can travel great distances at speeds of almost 500 mph and move on shore turbulently or merely rise quietly. The highest reported wave of 60 feet above sea-level resulted from a local earthquake on the island of Hawaii in 1868 (Macdonald et al, 1983). Much larger tsunamis have been reported elsewhere.

Thus tsunami hazard is probably localized to a zone of land at most 2 km wide around the coast, and at elevations below about 75 feet. This should not pose a significant danger to geothermal developments which are likely to be situated at higher elevations.

MEASURES TO MITIGATE DAMAGE FROM GEOLOGIC HAZARDS

Various methods which could be used to mitigate dangers from geologic hazards are listed below. No attempt is made to prioritize methods since priorities may differ with the risks at each specific site. A survey should be conducted on each development site to closely examine topography and structural integrity of the surface and sub-surface areas.

- Keep the power plant as far outside the rift zone as is possible since volcanic activity is concentrated there, e.g. lava flows, lava tubes, cracking, subsidence, pit craters, grabens, swelling. The piping distance from the well field to the power plant is limited due to increased thermal losses with distance; for example, the Kahauale'a site development map shows a maximum distance of about 2½ miles from its farthest well to a power plant.

- Power plants and wells should be constructed on the highest ground available. Even a very small hill or ridge could offer considerable protection from lava flows. Channels and valleys should be avoided, even if upslope, as lava flows tend to be channeled into and be deepest in these relatively low areas.
- If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from flow hazard, wells or plants can be sufficiently fortified to withstand almost any lava flow (Mullineaux and Peterson, 1974). A cost/risk analysis would have to be made.
- Another well-protection alternative is to enclose the well-head in a concrete cellar allowing the lava to flow above rather than around the well-head. Recovering a well covered with a thick flow could be quite arduous and time consuming. The precise effect the lava's heat would have on the well-head mechanisms is not known.
- To complement the platform a berm or wall could be constructed to divert lava flows. The embankment should be several meters high around the upslope and cross-slope sides of the structure. (See section on diversion walls below.)
- Available information indicates that the northern flank of Kilauea's rift zones are safer than the southern. For example, ground movements are more frequent on the Kilauea east rift zone's southern flank. By referring to figure 9 it is apparent that over the past 250 years the vast majority of erupted lava on Kilauea's rift zones has flowed over the southern slopes. Figure 10 depicts the percentage of ground covered by lava in the past 30 years, as distance varies north and south of the Kilauea east rift zone axis. A similar relationship does not appear to apply to volcanoes at other proposed geothermal areas in Hawaii.

- A geologic survey may identify near-surface lava tubes which could collapse under construction.
- Power plants should be modular and somewhat portable so that, if all fortifications fail, units might be salvaged and reused. This tends to encourage use of smaller decentralized plants.
- Steam transmission piping may be protected from a thin, fluid pahoehoe flow by installing downslope support structures. Thick aa flows would probably disrupt surface piping. Underground piping may offer more protection but installation and maintenance would be quite costly.
- Comprehensive evacuation plans should be designed to assure worker safety. Warning time prior to inundation can be as little as one hour (Moore, 1984). Procedures should be established to protect equipment. Multiple access roads should be provided in the event one gets covered by a flow.
- The development should coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory) and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. The developers have been giving this area their attention.
- If a lava flow is impending during well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing, portion of the well. These plugs can be installed in one hour (Niimi, 1984).
- Trip wires, placed in the expected path of a lava flow, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan (Niimi, 1984).
- Protecting structures or machinery against damage by pyroclastic fallout might be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong, having a sufficient pitch so that pyroclastic fallout does not

accumulate. Access to roofs should be easy so that, if necessary, they can be manually kept cleared of pyroclastic material.

- Plant generators can be specifically designed to be adjustable to some ground surface tilting or subsidence (Capuano, 1984).
- Steam transmission piping can be made with expansion joints to accommodate appreciable subsidence and ground movements.
- Plants should be constructed to withstand an earthquake of 7.5 (Stearns).
- Power plants should not be constructed in coastal regions, if risk from tsunami is to be avoided.
- In extraordinary and particular situations, bombing a lava channel may cut the feed to a flow-front and prevent or slow further advance in the front area (see section on bombing lava channels).
- If warranted by volcanic risk, adequate spacing between developments should be maintained so that one eruption would not likely endanger more than one development. It is a common utility practice to maintain reserves sufficient to prevent a major blackout. Reserve requirements (and associated costs) may be limited by using small decentralized power plants rather than one large plant.
- If geothermal development investors assume a major portion of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity.
- It is generally assumed that the resource developers will bear the risks of loss associated with their activities. However, if the utility owns the power plant, there may be some question as to whether the investors or the rate-payers will bear the risks of loss. This assumption of risk would be reflected in the cost of electricity from geothermal plants. It may be better that this cost be apparent "up front" rather than be delayed and possibly deferred to rate-payers in the event of a catastrophe. In the past, there have been some instances where hazard losses were recovered by the utility from rate revenues (e.g. Hilo tsunami of

1960). Policy regarding assigning and clarifying risks of loss may be implemented by imposing conditions to be met by development investors prior to the granting of a geothermal resource permit by the State (conservation district) or Counties (urban, rural, or agriculture districts).

PAST ATTEMPTS TO MITIGATE GEOLOGIC HAZARDS

CONSTRUCTION OF WALLS TO RESTRICT LAVA FLOWS IN KAPOHO, HAWAII

Macdonald (1962) wrote an excellent article on walls built to restrict lava flows during the 1959 and 1960 Kilauea eruptions. The 1960 eruption resulted in a flow of 113 million m^3 of lava, burying about 6 km^2 of land including most of Kapoho village. Both dams (which tend to impound flows) and diversion barriers (which alter flow course) were constructed. Diversion barriers are more likely to be successful in most situations.

Some of Macdonald's conclusions regarding the effectiveness and nature of the walls are presented:

- Walls must be constructed of heavy materials; not cinder as lava tends to burrow under it. Lava-rock is preferred; especially aa clinker since it is easily bulldozed and its spiny character allow them to bind well.
- Walls must have a broad base and adequate height to prevent overflow; e.g. if flow is 10 m thick, the base should be about 30 m wide.
- Outwide walls should be gently sloped to lessen erosion should an overflow develop.
- If the wall is a diversion barrier, a smooth unobstructed path or channel should be along the inside of the wall to promote diverted flow. In addition, the channel must also have sufficient slope to promote flow, i.e. at least 2 percent.

- Yielding of walls to lava pressure was limited to only a few places where wall was built from light cinder.

Macdonald summarizes the success of the Kapoho walls by noting that "they have demonstrated that properly constructed walls will endure the thrust of even thick lava flows without yielding; and that walls with adequately sloping clear channels behind them will successfully change the course of a flow." Others believe that "structures of sufficient size and strength could be constructed to divert lava flows as large as any historic flow...if the need were great enough a carefully planned, small-scale system might be feasible and effective" (Mullineaux and Peterson, 1974).

USE OF LAVA DIVERSION WALLS AND EXPLOSIVES ON MOUNT ETNA, ITALY

In 1983, lava flows from Mt. Etna in Italy threatened two towns downslope of an active vent (Figure 16A). In response to the situation, a lava diversion program was initiated to mitigate damages from the lava flows. This included two diversion barriers and the use of explosives.

With explosives, it was intended to create a significant diverting leak in a channel supplying lava to the flow front. A portion of the lava channel was removed by heavy equipment to provide for proper placement of the explosives (Figure 16B). It was observed that efforts to cool the drill (using water and dry ice) cooled the lava, thereby reducing the cross-sectional area of the lava tube and causing the lava to "back-up" and overflow the lava tube; this resulted in some unintended but welcomed lava diversion. 400 kg of explosives were finally inserted and detonated which caused a small lava flow away from the main lava tube.

The diversion barriers were quite substantial (Figure 16C); one being 150,000 m^3 and 500 m long, the other 120,000 m^3 and 300 m long. Work continued while lava was accumulating on the interior of the diversion wall. The first barrier, though eventually overtopped, caused major channels to be diverted from one town. The second barrier also succeeded in diverting the lava away from a second town.

This effort was quite substantial, utilizing 100 pieces of major equipment and over 100 men (working 90 hours per week), at a cost of $3 million. However, savings due to prevention of property loss were estimated at $5-25 million. (See Williams and Moore, 1977.)

PUMPING WATER ON LAVA FLOWS IN KAPOHO, HAWAII

Water may chill and partially congeal a flow margin. During the 1960 Kapoho flow, the Hawaii Fire Department pumped water on the flow margin. Macdonald (1962) found that "it was possible to locally check the advance of the flow margin. Although the check is temporary, it is sometimes possible in that way to gain the short time--up to several hours--that may be needed to remove furnishings or other materials from a building, or even to remove the building itself."

This has obvious application to a geothermal development. If warranted, a sufficient supply of water might be kept on hand for lava cooling purposes; possibly from the same source as the power plant cooling water. The amount of rainfall in geothermal areas should also be considered (e.g. figure 5).

PUMPING WATER ON LAVA FLOWS ON HEIMAEY ISLAND, ICELAND

In 1973, when lava flows threatened a coastal town on Heimaey Island, Iceland, a program was designed to: (1) slow advancing lava by pumping great volumes of seawater over the flow and (2) divert the lava flow using a diversion barrier. The water-pumping program was the largest ever attempted. Seventy-five men working at times around the clock, sprayed approximately 7.3 million cubic yards of seawater onto the lava flow at a cost of $1.5 million. The pumped water converted 5.5 million cubic of molten lava into solid rock, cooling the lava 50 to 100 times more rapidly than self-cooling. A specialized system of pumps and piping was utilized. (See Lockwood, 1983.)

BOMBING OF LAVA CHANNELS ON MAUNA LOA, HAWAII

This technique can only be used in appropriate situations, i.e. to break-down walls of near-vent lava channels, clogging them, thereby lessening the supply of lava to distal lava flow fronts. This would promote spreading of the flow in the bombed areas. Bombing of Mauna Loa flows was tried twice; but was not particularly useful in those situations (Macdonald, 1962). The legal ramifications of damages caused by diverting flow paths should be explored.

EMERGENCY PLANNING AT THE GEOTHERMAL DEVELOPMENT IN KRAFLA, ICELAND

In 1975 an emergency situation developed at Krafla, in Northern Iceland. A geothermal power plant under construction was located within 1 km of the locus of ground deformation and seismic activity of the type that proceeds volcanic eruptions. This activity continued for over five years with construction proceeding normally though several small lava eruptions occurred within 2 km of the plant. Careful contingency plans were designed for the evacuation of site workers, but the lava flows did not directly contact the power plant. On one occasion lava did rise into one of the well bore-holes without significant effect. Construction was concluded and the geothermal development is now operating.

This particular development is sited in a rift zone similar to the Hawaiian rift zones. Detailed emergency planning should draw upon the contingency plans which resulted from this experience in Iceland (see Tryggvason, 1973).

GEOLOGIC HAZARD ANALYSIS

MAUI

A Maui volcanic hazard map has been prepared by D. Crandell (1983) which describes the frequency of past eruptions.

Haleakala Southwest Rift Zone

Flows range from 200 to 20,000 years old. Six flows have erupted in this area within the last 1000 years. Based on past activity, the average rate of eruption is one per 150-200 years. The last flow occurred in 1790 by the coast; it was the largest (6 km^2) of the more recent flows. See figures 6 and 7.

Haleakala East Rift Zone

The most recent flow on the east side of Haleakala is just north of this geothermal resource area between Olopawa and Puu Puou; it is about 500 years old. Based on past activity, the average rate of eruption is one per 10,000 years.

The above risk from volcanic hazards includes dangers from lava flows and other attendant phenomenon such as pyroclastic fallout, cracking, subsidence, swelling, and emission of volcanic gases.

The most recent earthquake near Maui occurred in 1938, 40 miles off the northern coast of East Maui. Some damage to roads and buildings on Maui and Molokai was reported (Macdonald et al, 1983). Cracking and subsidence may also be associated with large earthquakes.

Crandall (1983) states that although Haleakala's "eruptive history suggests that an eruption could occur on Haleakala within the next hundred years, there is as yet no way to predict a specific time or place of the next eruption."

HAWAII

Figures 8 through 11 show the locations of historic lava flows and fault systems. Figures 12 through 15 show relative zones of risk from flows, fallout, subsidence, and ruptures.

Hualalai

The only historic eruption of Hualalai occurred in 1801. It produced two large flows covering 46 km^2 east and north towards the ocean.

Several thousand earthquakes, from a source beneath Hualalai, shook the island in 1929. This may indicate subsurface magmatic movement or a readjustment or settling of the mountain.

Eruptions and earthquakes (and associated cracking, fallout, subsidence, etc.) may occur here in the future but it is not possible to predict the precise time and place of future activity.

Mauna Loa Southwest Rift Zone

- There have been 7 eruptions on the southwest rift zone since 1832; an average of one eruption every 22 years.
- The latest and largest flow occurred in 1950 covering an area of 91 km^2. The average flow has been about 34 km^2.
- Hawaii's largest earthquake (magnitude 7.5) occurred in 1868 near the southern tip of the island.
- Eruptions and earthquakes (and associated hazards of ash fallout, ground deformation, cracking, and subsidence) are likely to occur here in the future but it is not possible to predict the precise time and location of future activity.
- There is no danger from tsunami in this geothermal resource area since its lowest elevation is about 1500 feet.

Historic Eruptions of Mauna Loa Southwest Rift

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
Mar. 1868	15	--	990	223.7	140,000,000	5.9
Jan. 1887	10	226	1710	29.4	220,000,000	7.5
Jan. 1907	15	240	1860	21.1	75,000,000	3.5
May 1916	14	112	2220	17.2	60,000,000	3.5
Sept. 1919	42	41	2310	23.9	255,000,000	10.7
Apr. 1926	14	77	2280	34.8	110,000,000	3.2
June 1950	23	290	2400	91.0	440,000,000	4.8
Total	95	986		241.1	1,300,000,000	
Average	14	164 (13.7 yrs)	1967	34.4	186,000,000	6.3 (21 ft)

Source: Modified after Macdonald, et al, (1983).

Mauna Loa Northeast Rift Zone

- There have been 7 eruptions on the northeast rift zone since 1832; an average of one every 22 years. Most eruptions originated at elevations higher than the proposed 7000' resource area cut-off; but flows commonly travel into this area.
- The largest flow, in 1880, covered an area of 62 km^2. The average flow has been about 37 km^2.
- The most recent flow, in Spring 1984, covered an area of over 30 km^2 and stopped close to Hilo, Hawaii.
- Earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, e.g. magnitude 6.7 in November 1983.
- Eruptions and earthquakes (and associated hazards of ash fallout, ground deformation, cracking, subsidence, etc.) are likely to occur here in the future but it is not possible to predict the precise time and place of future activity.

- There is no danger from tsunami in this geothermal resource area since its lowest elevation is about 3500 feet.

Historic Eruptions of Mauna Loa Northeast Rift

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
Feb. 1852	20	--	2520	28.6	100,000,000	3.5
Aug. 1855	450	40	3150(?)	31.7	110,000,000	3.5
Nov. 1880	280	288	3120	62.4	220,000,000	3.5
Jul 1899	19	215	3210	42.1	145,000,000	3.5
Nov. 1935	42	435	3630	35.9	115,000,000	3.2
Apr. 1942	13	76	2760	27.6	75,000,000	2.7
Mar. 1984	--	503	3600	30+	300,000,000	4.8
Total	824	1557		258+	1,065,000,000	
Average	137 (4.5 mo.)	260 (22 yrs)	3141	37	152,000,000	3.5 (11½ ft)

Source: Modified after Macdonald, et al, (1983).

Kilauea Southwest Rift Zone

- There have been 5 eruptions on the southwest rift zone since 1750; an average of one every 47 years.
- The largest flow, in 1919, covered an area of 13 km^2. The average flow has been about 7 km^2.
- The most recent volcanic activity occurred in 1982, when magma moved into the rift zone. This caused ground cracking but no lava erupted.
- The southern flanks of Kilauea's rift zones are more prone to be covered by lava flows than are the north flanks due to its topography (see Figure 9).

- Earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983.
- Eruptions and earthquakes (and associated hazards of ash fallout, ground deformation, cracks, subsidence, etc.) are likely to occur here in the future; but it is not possible to predict the precise time and place of future activity. Intervals between historic eruptions in the southwest rift zone have varied from 3 years (1971 to 1974) to 52 years (1919 to 1971).
- There may be some danger from tsunami and ground subsidence in the coastal portion of this geothermal resource area.

Historic Eruptions of Kilauea Southwest Rift

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
May 1823	Short	--	400	10	11,000,000	1.1
Apr. 1868	Short	539	770	.1	183,000	1.8
Dec. 1919	221	620	900	13	45,300,000	3.5
Sep 1971	5	615	1000	3.9	7,700,000	2.0
Dec. 1974	1	38	1080	7.5	14,300,000	1.9
Total		1812		34.5	78,483,000	
Average	Short	453 (38 yrs)	830	6.9	16,000,000	2.7 (9 ft)

Source: Modified after Macdonald, et al, (1983).

Kilauea Upper East Rift Zone

For purposes of this hazard analysis the east rift zone is divided into upper and lower segments. A line extending roughly north of Kalapana distinguishes these two areas (see line A-A, figure 8). Eruptions at the caldera area were not considered as a rift zone eruption.

- There have been 21 eruptions on the upper east rift zone since 1750; an average of one every 11 years.
- The largest flow, the Mauna Ulu flow of 1972, covered an area of 35 km^2. The average flow has been about 6 km^2. However, the greater volumes of the more recent eruptions may be a better guide to future events than the generally small-volume historic eruptions prior to 1969.
- The current Pu'u O eruption has covered an area over 30 km^2. This eruption began in January 1983 and has been through 23 phases so far. The localized present danger will subside after the Pu'u O eruption is determined to have ended by qualified geologists.
- The southern flanks of Kilauea's rift zones are much more prone to be covered by lava flows than are the north flanks due to its topography (see Figure 9). Figure 10 graphically depicts the percentage of ground covered by lava flows, from 1954 to 1984, as it varies with distance north and south of the rift zone axis.
- The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana. It resulted in cracking, subsidence, and tsunami (Macdonald et al, 1983).
- Most volcanic cracking and subsidence are centered about the rift zone. However, there is considerable faulting associated with the Koae and Hilina fault system south of the caldera (See Figure 3).
- There may be some danger from tsunami and ground subsidence in the coastal portion of this geothermal resource area.
- As Kilauea is highly active, eruptions and earthquakes (and associated hazards of ash fallout, ground deformation, cracks, subsidence, etc.) will occur here in the future; but it is not possible to predict the precise time and place of future activity. Intervals between historic eruptions in the upper east rift zone have varied from days apart (1973) to 38 years (1923 to 1961).

Historic Eruptions of Kilauea Upper East Rift*

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
May 1840	26	--	900	3.4**	41,000,000**	12
May 1922	2	983	800	.1	?	--
Aug. 1923	1	16	900	.5	73,000	.2
Sep 1961	3	456	500	.8	2,200,000	2.8
Dec. 1962	2	15	950	.1	310,000	3.1
Aug. 1963	2	9	900	.2	800,000	4.0
Oct. 1963	1	2	900	3.4	6,600,000	1.9
Mar. 1965	10	17	750	7.8	16,800,000	2.2
Dec. 1965	1	9	920	.6	850,000	1.4
Aug. 1968	5	40	650	.1	130,000	1.3
Oct. 1968	15	2	850	2.1	6,600,000	3.1
Feb. 1969	6	4	900	6.0	16,100,000	2.7
May 1969	867	3	940	12.5	176,700,000	14.1
Feb. 1972	455	4	940	35.1	119,600,000	3.4
May 1973	1	0	990	.3	1,200,000	4.0
Nov. 1973	30	6	925	1.0	2,700,000	2.7
Dec. 1973	203	0	940	8.1	28,700,000	3.5
July 1974	3	0	1040	3.1	6,600,000	2.1
Sep. 1977	18	38	550	7.8	32,900,000	4.2
Nov. 1979	1	25	970	.3	580,000	1.9
Jan. 1983	520+	39	750	30+	200,000,000+	6.7
Total	2172	1668		126	667,643,000	
Average	103 (3.5 mo.)	83 (7 yrs)	855	6	32,000,000	7.6 (25 ft)

* In this report, a line extending roughly north of Kalapana distinguishes the lower and upper east rift zone (see Figure 8). Eruptions in the caldera area were not considered as a rift zone eruption.

**The 1840 flow occurred roughly 1/5 within the upper east rift and 4/5 within the lower east rift; the appropriate fractional portion is shown in the table.

Source: Modified after Macdonald, et al (1983).

Kilauea Lower East Rift Zone

- There have been 5 eruptions on the lower east rift zone since 1750; an average of one every 47 years.
- The largest flow, in 1955, covered an area of 16 km^2. The average flow has been about 11 km^2.
- The most recent flow, in 1960, covered an area of about 11 km^2 near and in Kapoho.
- The southern flanks of Kilauea's rift zones are much more prone to be covered by lava flows than are the north flanks due to its topography (see Figure 9). Figure 10 graphically depicts the percentage of ground covered by lava flows, from 1954 to 1984, as it varies with distance north and south of the rift zone axis.
- Intervals between historic eruptions have varied from 5 years (1955 to 1960) to 115 years (1840 to 1955). It is not possible to predict the precise time and place of future eruptions.
- The earthquake of 1868 on the southern tip of the island was the largest earthquake in this area (magnitude 7.5).
- There may be some danger from tsunami and ground subsidence in the coastal portion of this geothermal resource area.

Historic Eruptions of Kilauea Lower East Rift*

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
1750 (?)	--	--	510	4.1	14,200,000	3.5
1790 (?)	--	480	300	7.9	27,500,000	3.5
May 1840	26	605	350	13.8**	164,000,000**	11.9
Feb. 1955	88	1384	175	15.9	87,600,000	5.5
Jan. 1960	36	56	35	10.7	113,200,000	10.6
Total		2525		52.4	406,500,000	
Average	50	631 (53 yrs)	274	10.5	81,000,000	9.5 (31 ft)

* In this report, a line extending roughly north of Kalapana distinguishes the lower and upper east rift zone (see Figure 8). Eruptions in the caldera area were not considered as a rift zone eruption.

**The 1840 flow occurred roughly 1/5 within the upper east rift and 4/5 within the lower east rift; the appropriate fractional portion is shown in the table.

Source: Modified after Macdonald, et al, p. 64 (1983)

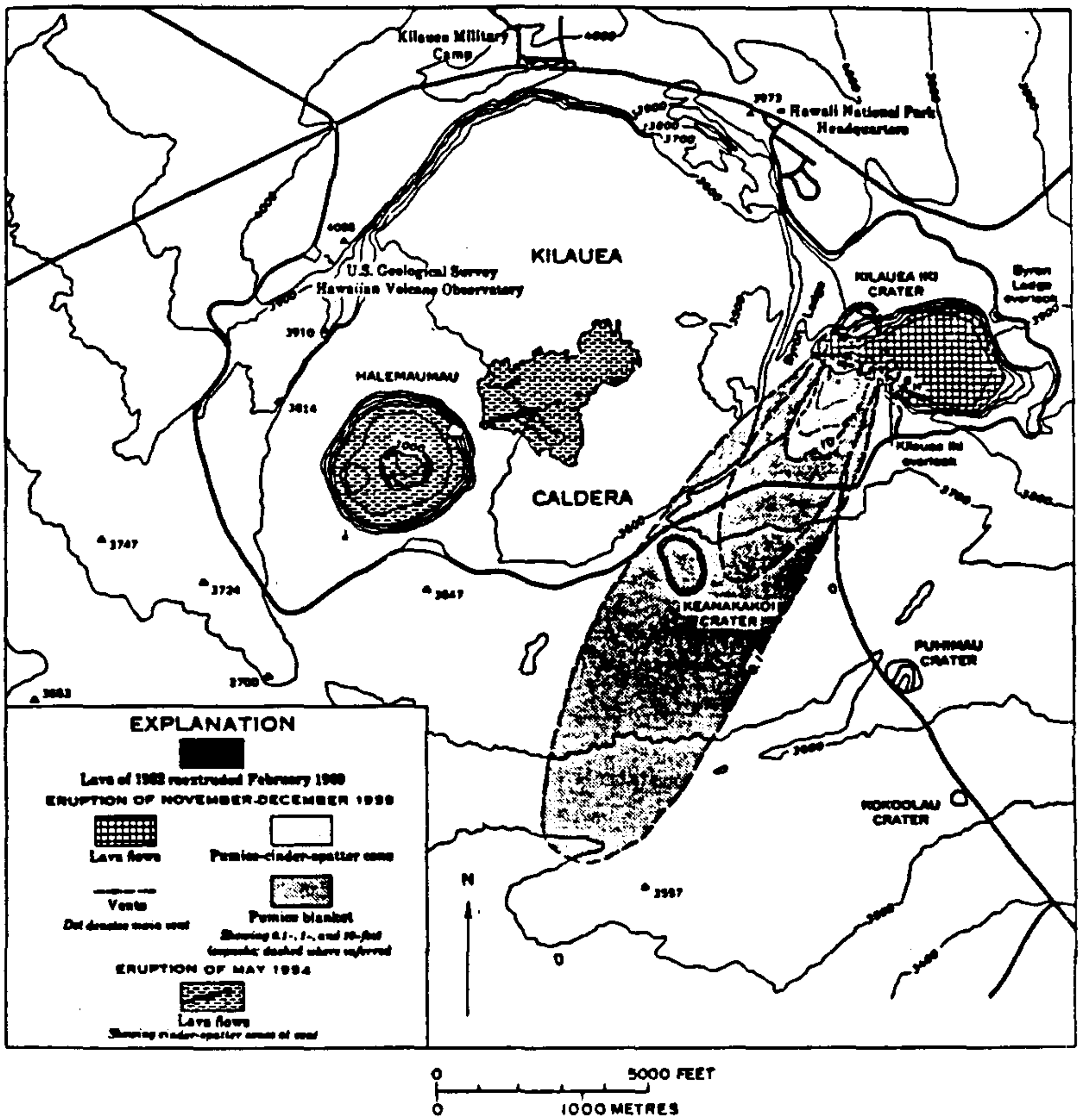


Figure 1. Map of the Kilauea summit area, showing extent of pumice blanket from Kilauea Iki vent in 1959. (In Mullineaux and Peterson, 1974, from Richter and others, 1970)

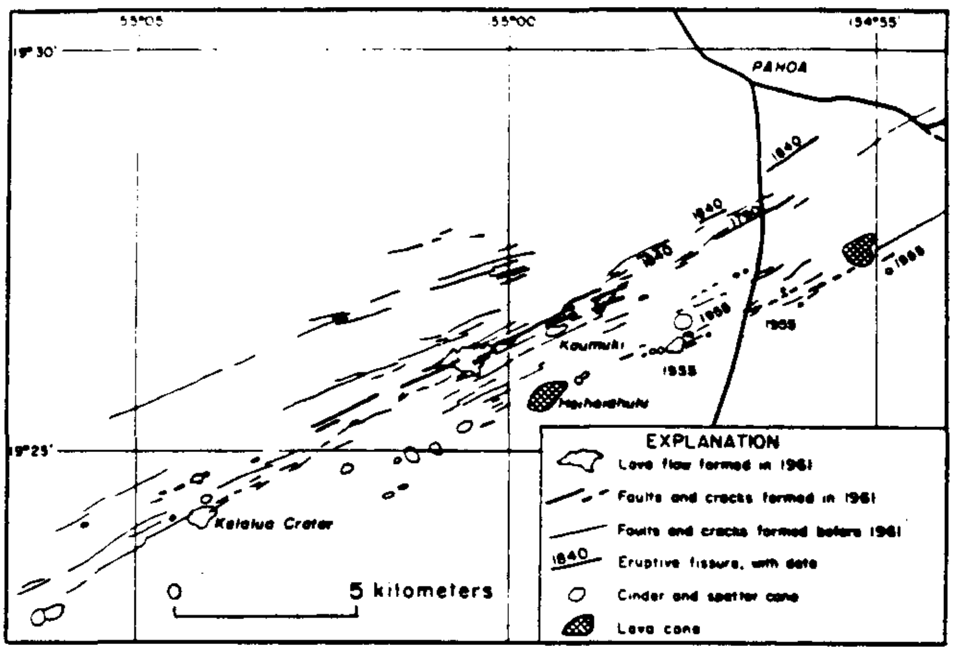


Figure 2. Map of part of the east rift zone of Kilauea showing faults, cracks, and lava flows formed in 1961. (In Holcomb, 1980; modified after Richter et al., 1964)

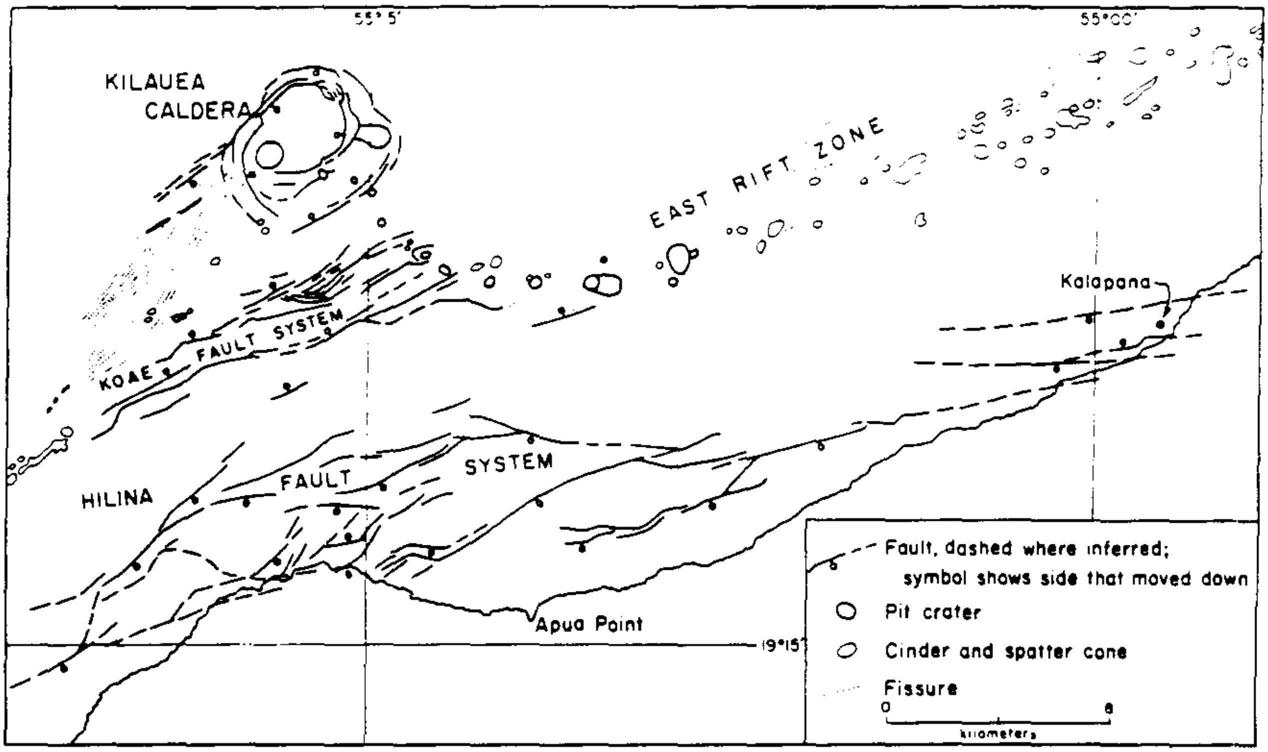


Figure 3. Map showing the pattern of faults in the Hilina fault system, on the southern flank of Kilauea volcano. (In Macdonald et al., 1983; modified after Stearns and Macdonald, 1946)

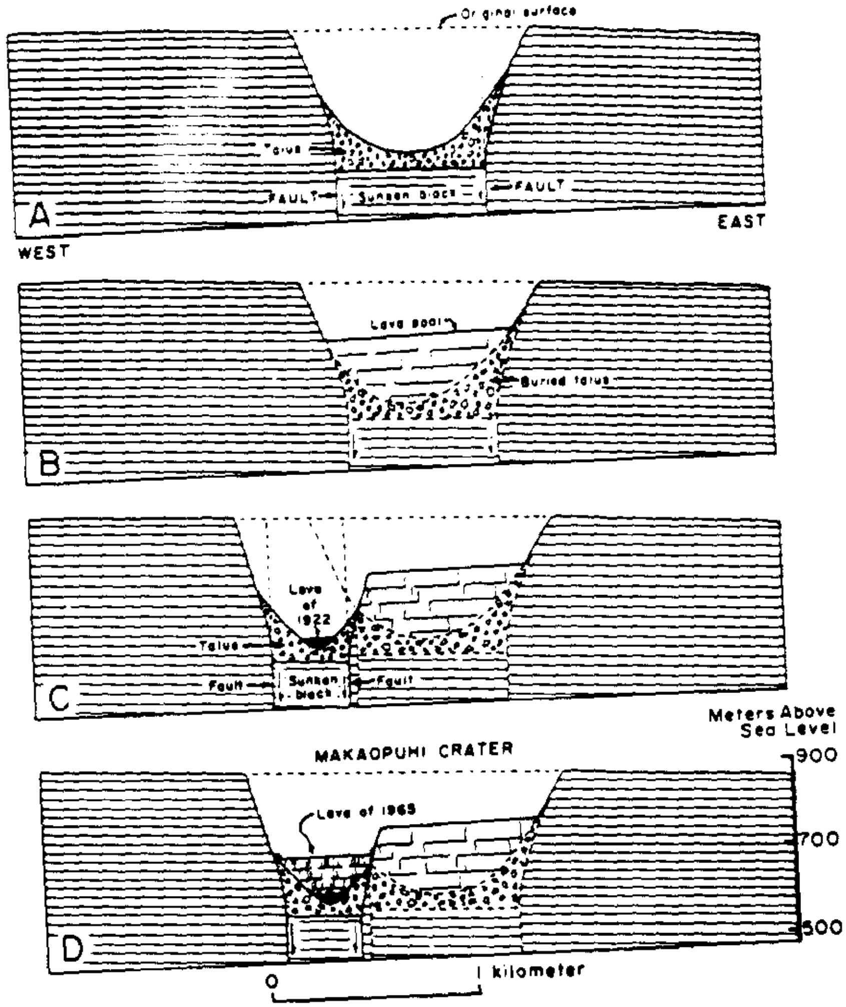


Diagram showing the manner of formation of Makaopuhi, a double pit crater. *A*, A subcircular fault block sinks, leaving a crater at the surface. (The position and attitude of the faults is hypothetical.) The upper walls of the crater collapse to form taluses (piles of rock fragments) that hide the lower walls. *B*, Lava pouring into the crater collects in a deep pool, the surface of which solidifies to form a nearly flat floor. *C*, A second block sinks, making a second crater that cuts across the western edge of the first one. The pool of lava in the bottom of the second crater is from a small eruption in 1922. *D*, A much larger eruption (in 1965) forms a pool 90 meters deep in the second crater. Note the slump scarps at the edge of the new lava floor, formed as lava in the central part of the crater drains back into underlying vents.

Figure 4. Formation of pit craters. (Macdonald et al., 1983)

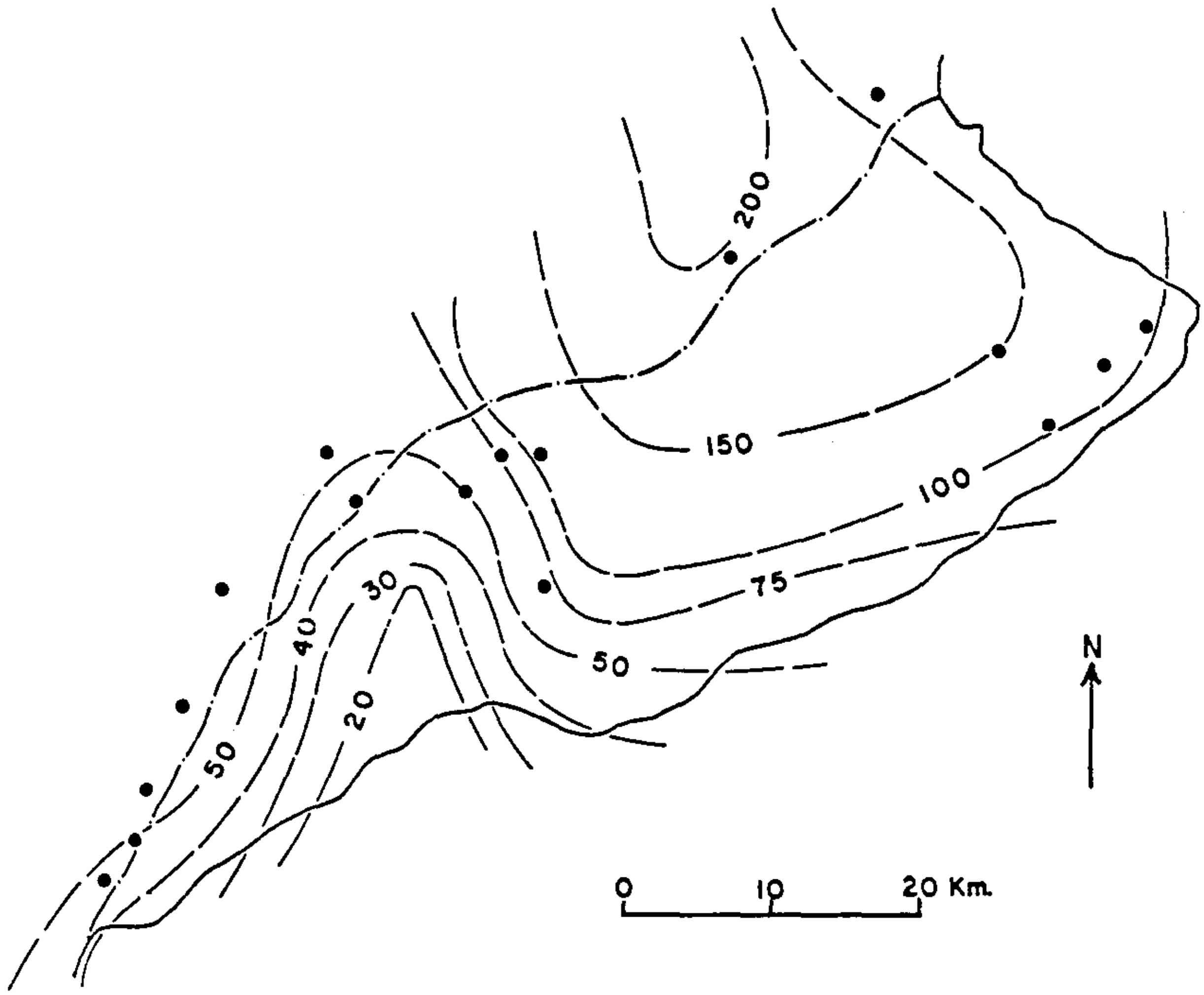


Figure 5. Rainfall of Kilauea. (In Holcomb, 1980; after Taliaferro 1959)

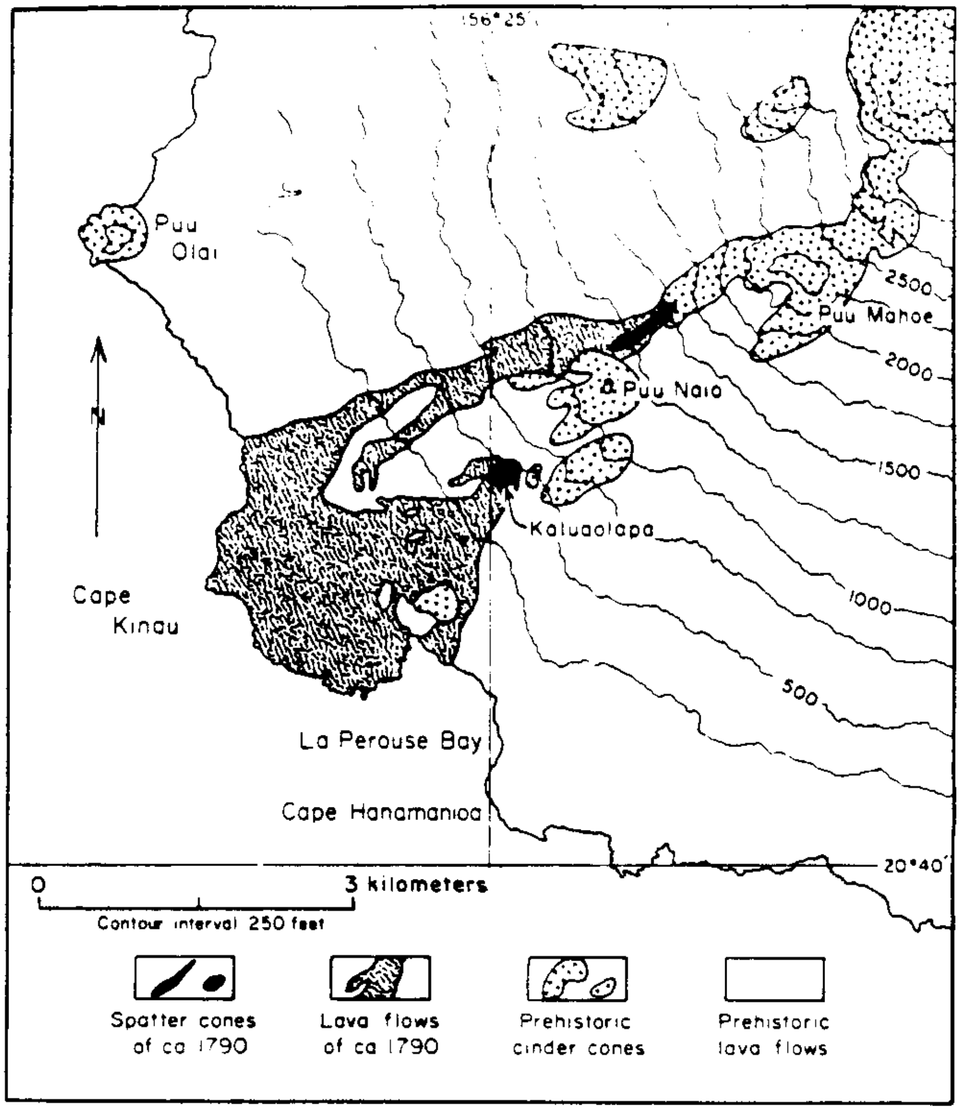


Figure 6. Map of the southwestern part of Haleakala volcano, island of Maui, showing the lava flows of the 1790 eruption and the spatter cones at their vents. (In Macdonald et al., 1983; modified after Stearns and Macdonald, 1942)

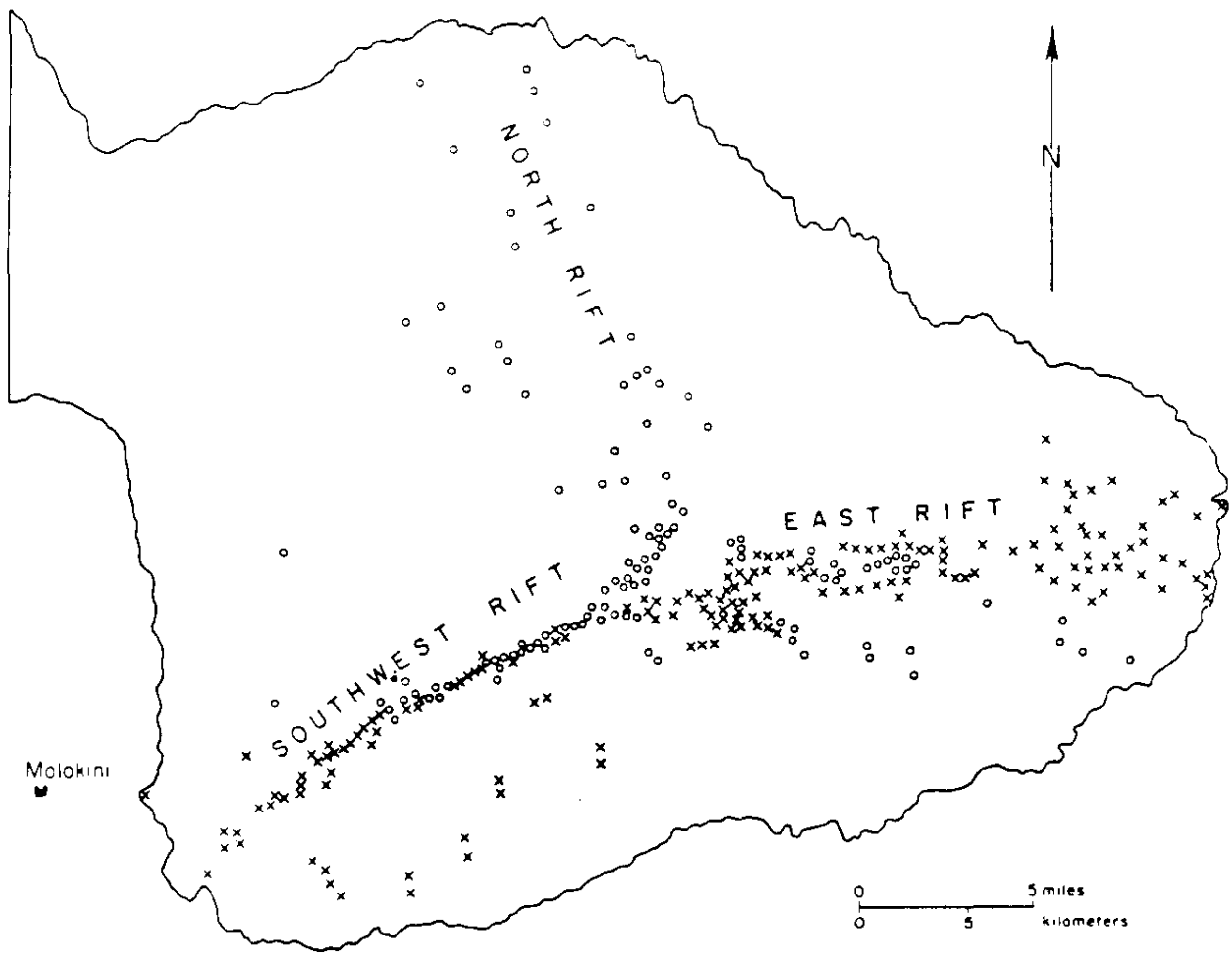


Figure 7. Map of Haleakala volcano, showing vents of the Kula (circles) and Hana (crosses) Volcanic Series. Molokini Islet is a tuff cone on the southwest rift zone of Haleakala. (In Macdonald et al., 1983; after Stearns and Macdonald, 1942)

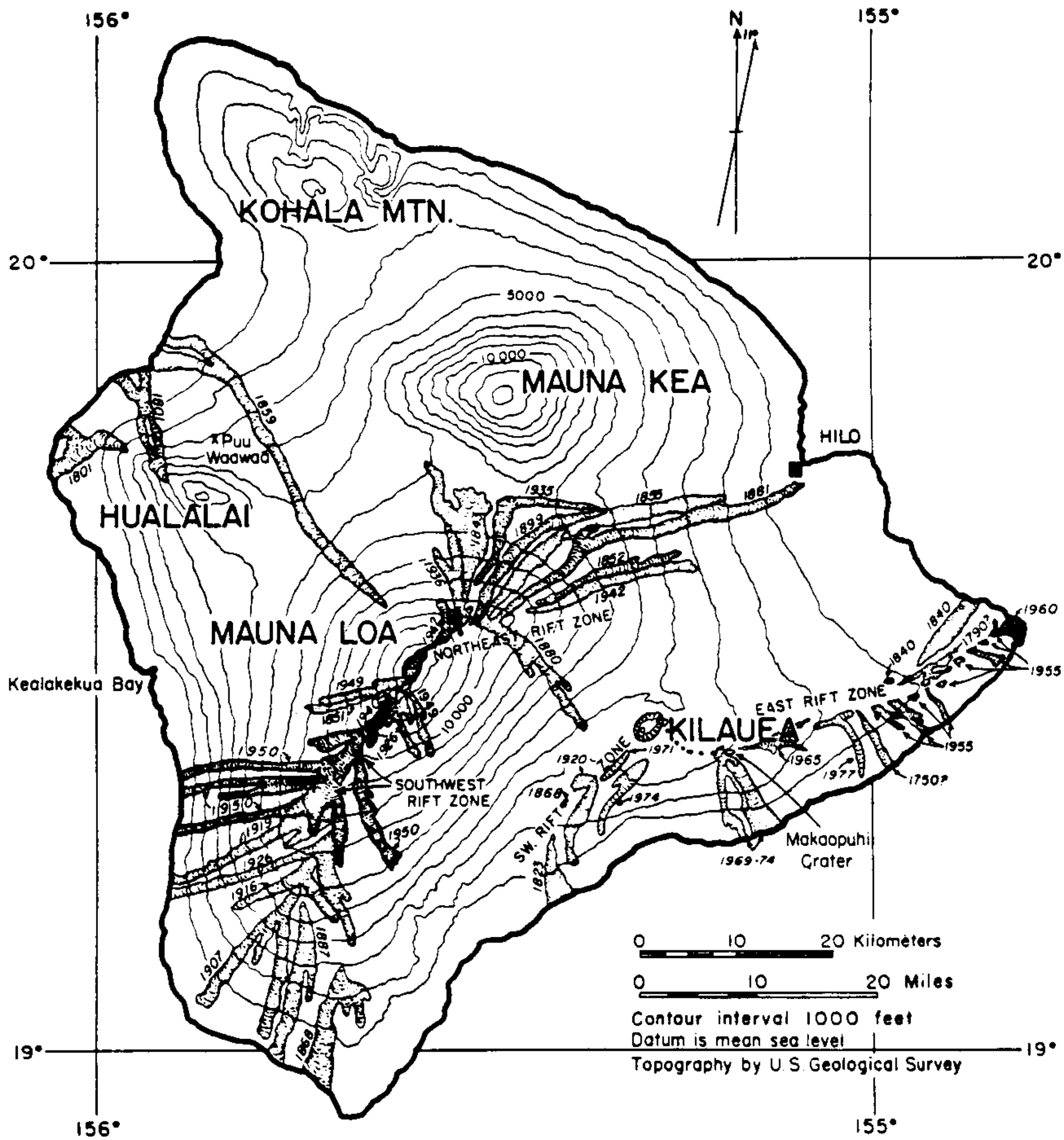


Figure 8. Map of the island of Hawaii, showing the five major volcanoes that make up the island, and the historic lava flows. (Macdonald et al., 1983)

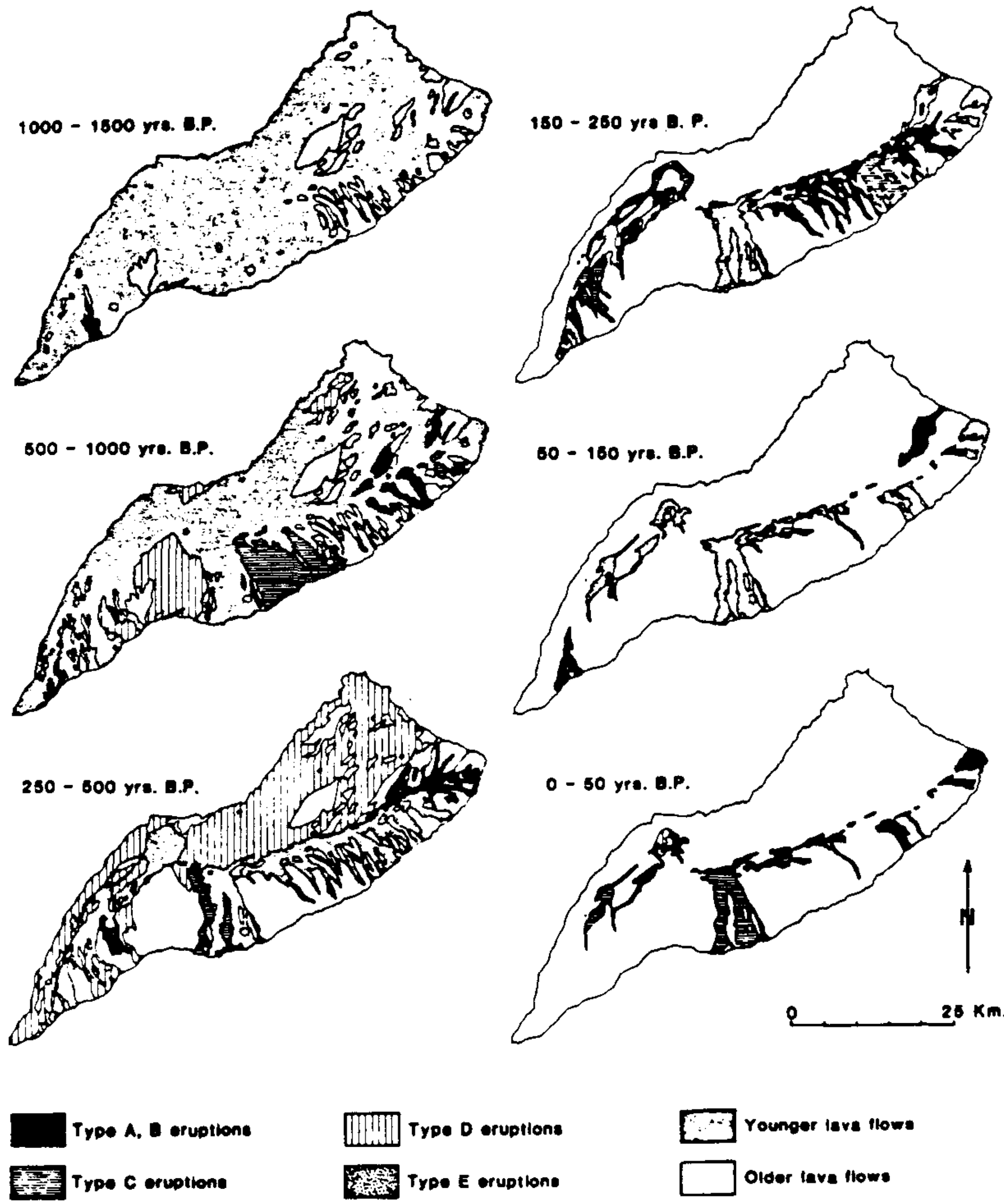


Figure 9. Summary of Kilauea's eruption history during the last 1500 years. (Holcomb, 1980)

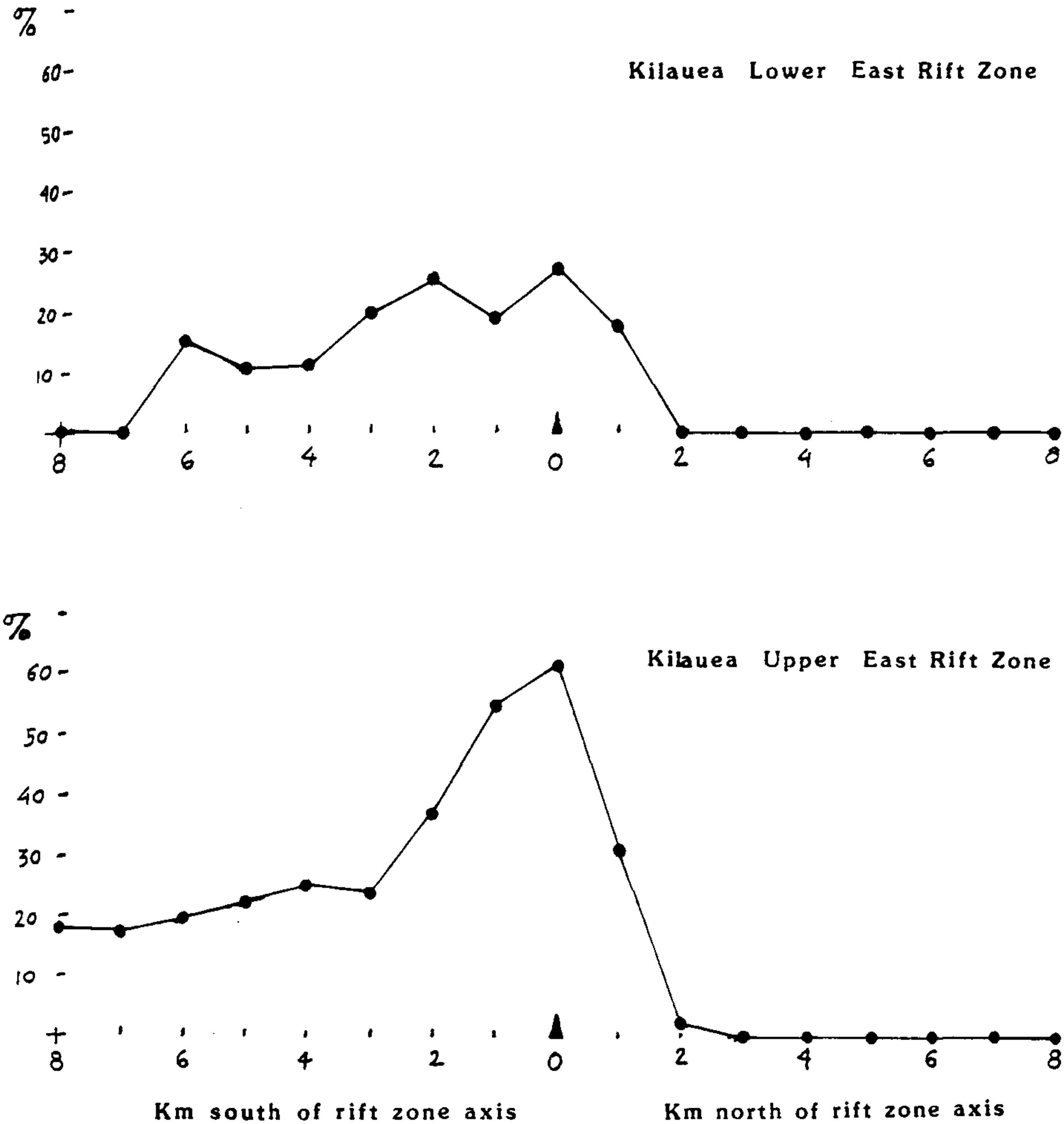


Figure 10. Percentage of ground covered by lava flows, from 1954 to 1984, as it varies with distance north and south of Kilauea's east rift zone axis. If 30 years is the assumed life of a geothermal power plant, these figures suggest the probability that sites may be threatened by burial during their lifetime, as based on Kilauea's history from 1954 to 1984.

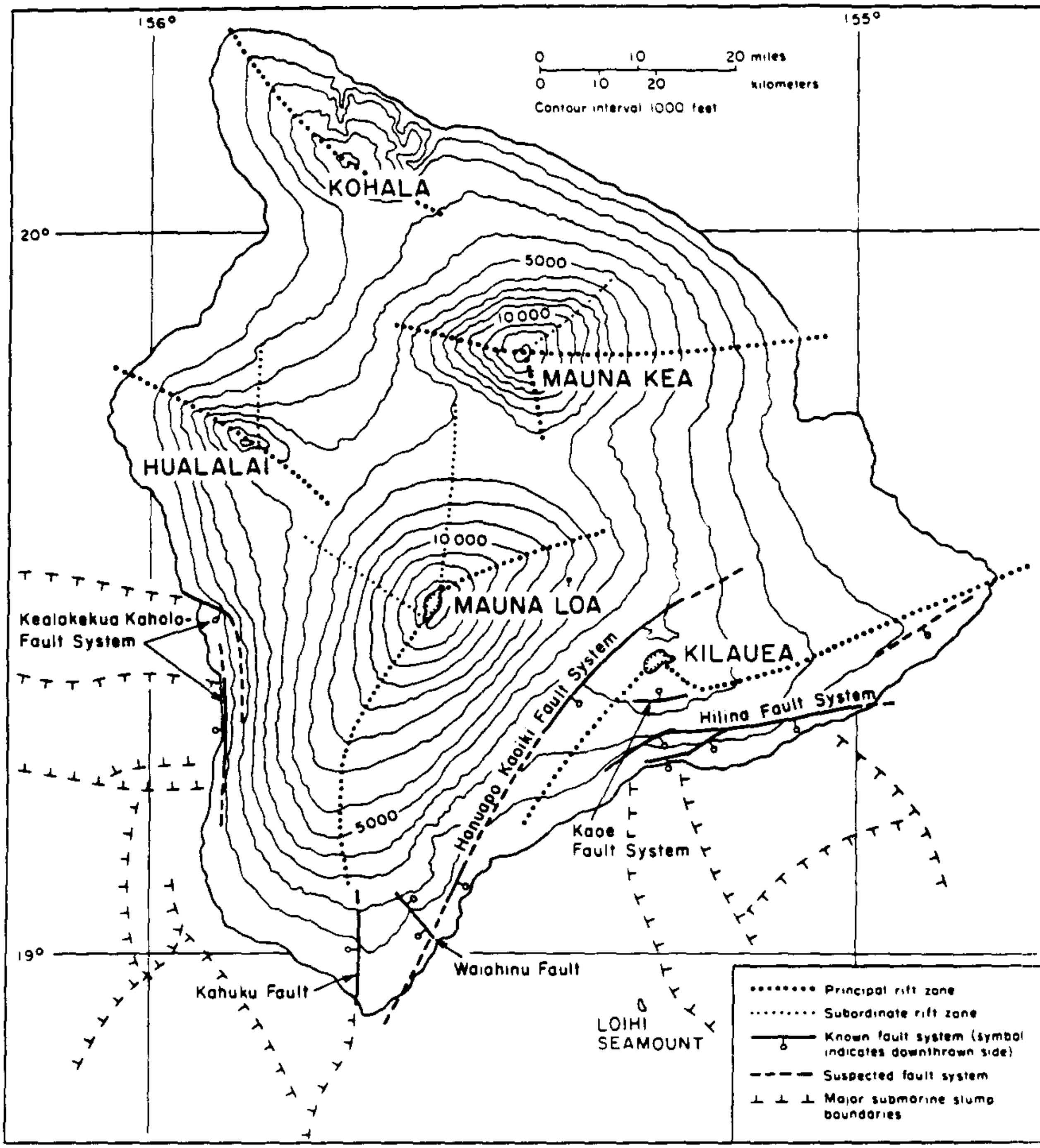


Figure 11. Map showing volcanic rift zones and faults on the island of Hawaii. (In Macdonald et al., 1983; submarine slumps after Normark et al., 1978)

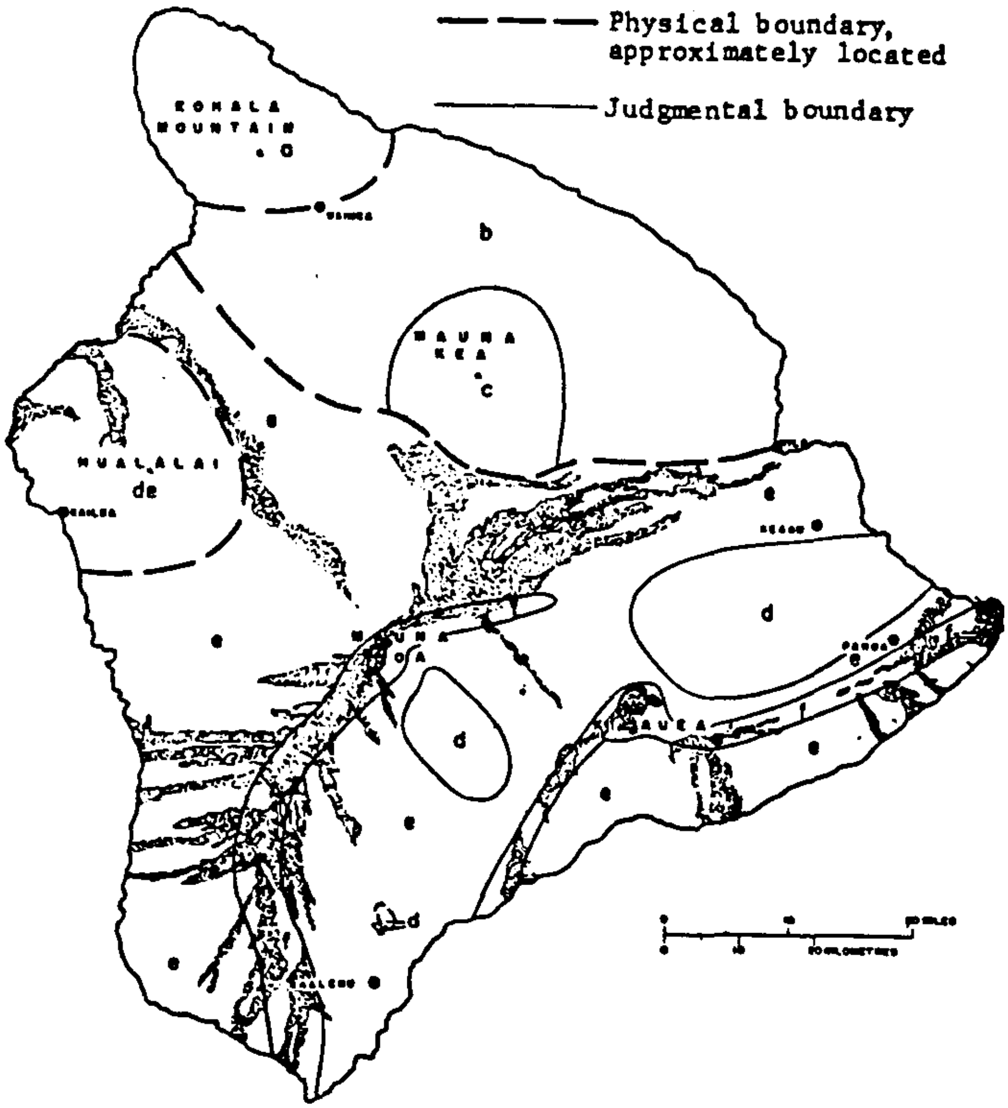


Figure 12. Zones of relative risk from lava-flow burial. Risk increases from "a" through "f". (Mullineaux and Peterson, 1974)

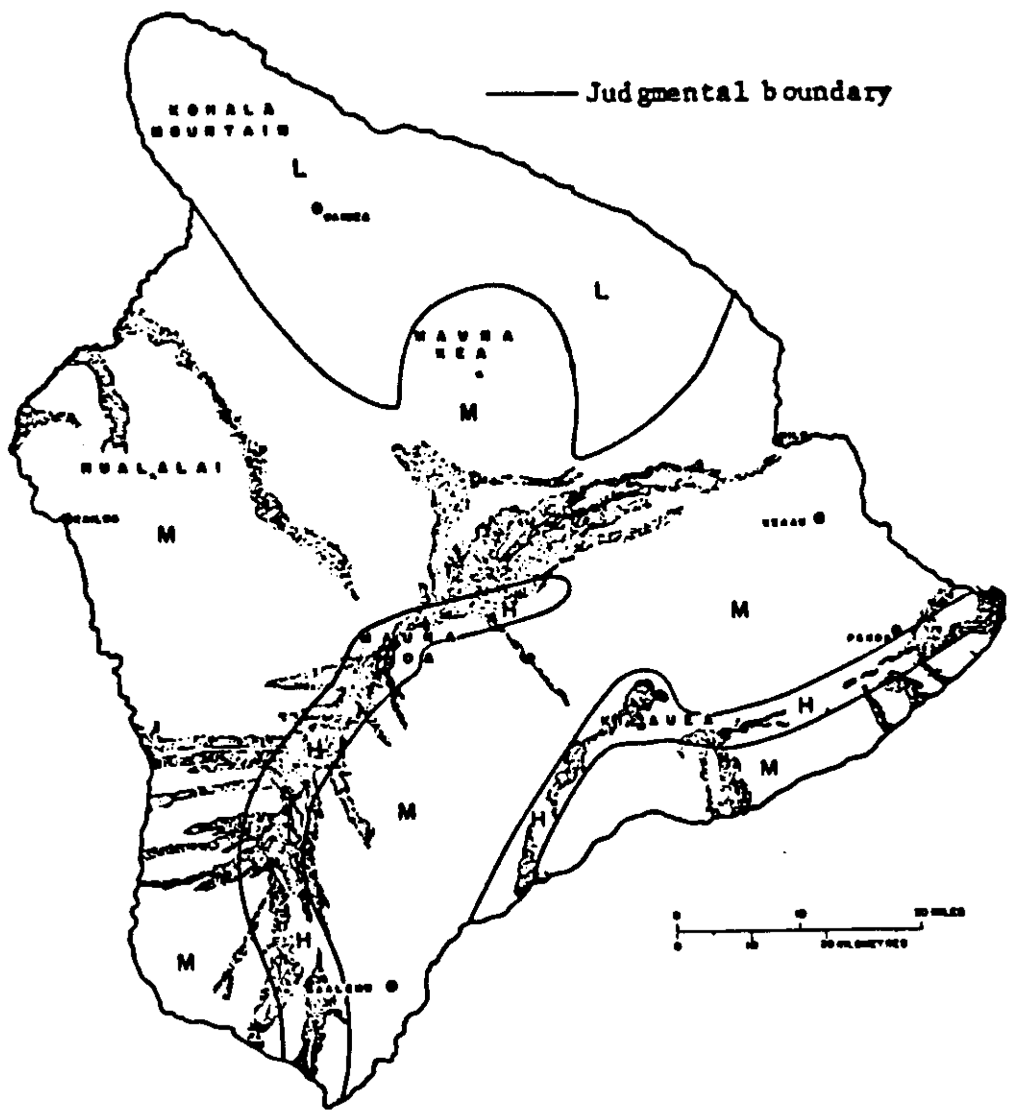


Figure 13. Zones of relative risk from falling volcanic fragments: H, high; M, medium; L, low. (Mullineaux and Peterson, 1974)

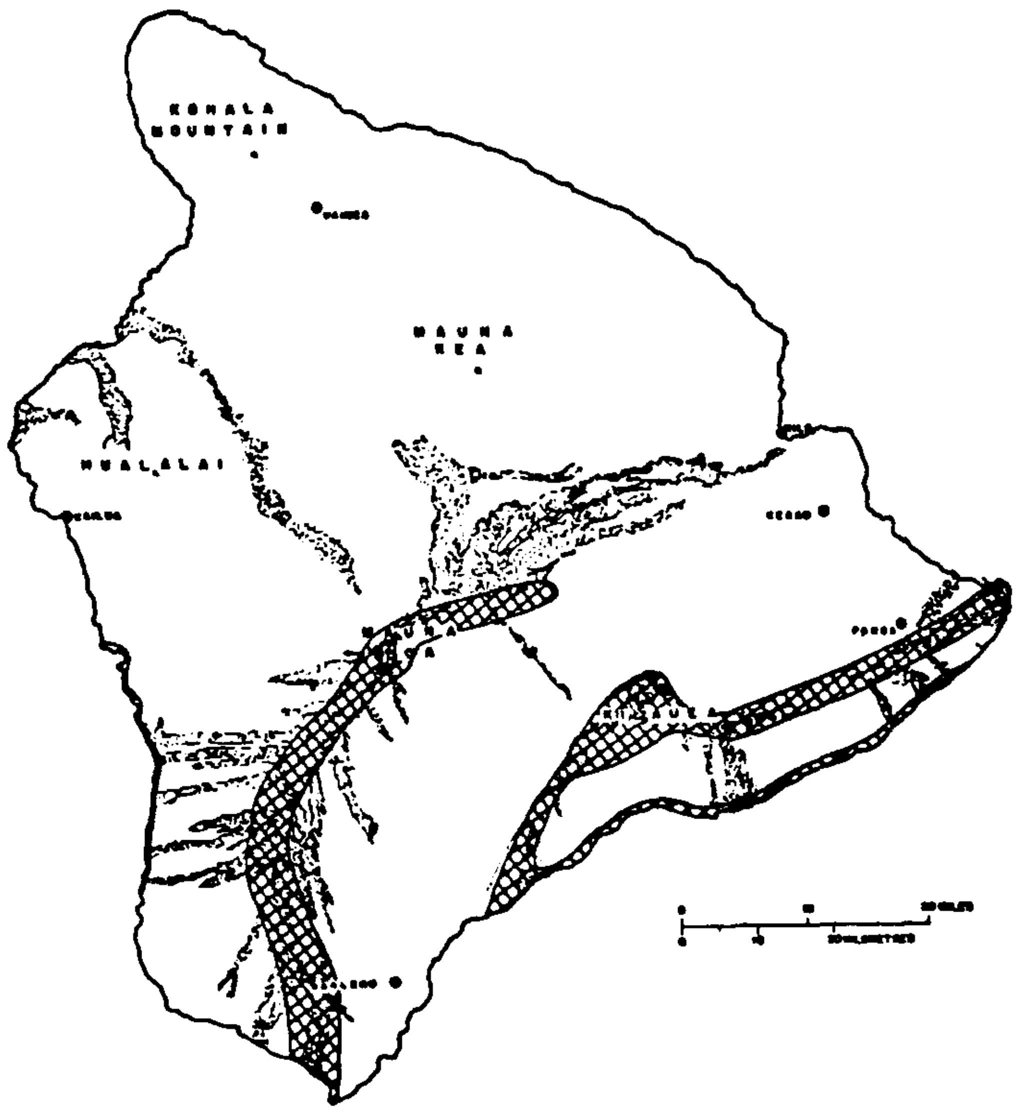


Figure 14. Volcano rift and shoreline zones subject to relatively high risk from subsidence (cross hachured). (Mullineaux and Peterson, 1974)

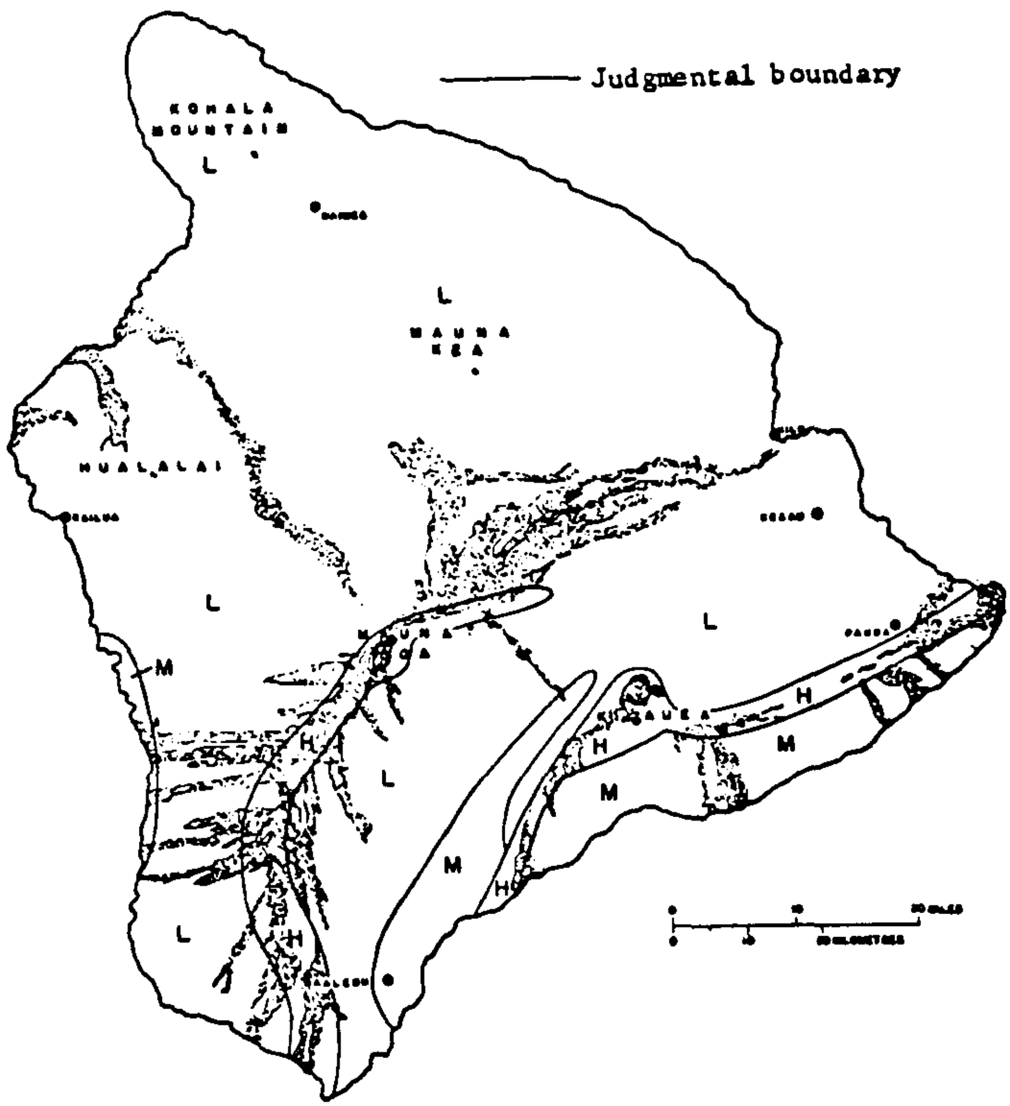
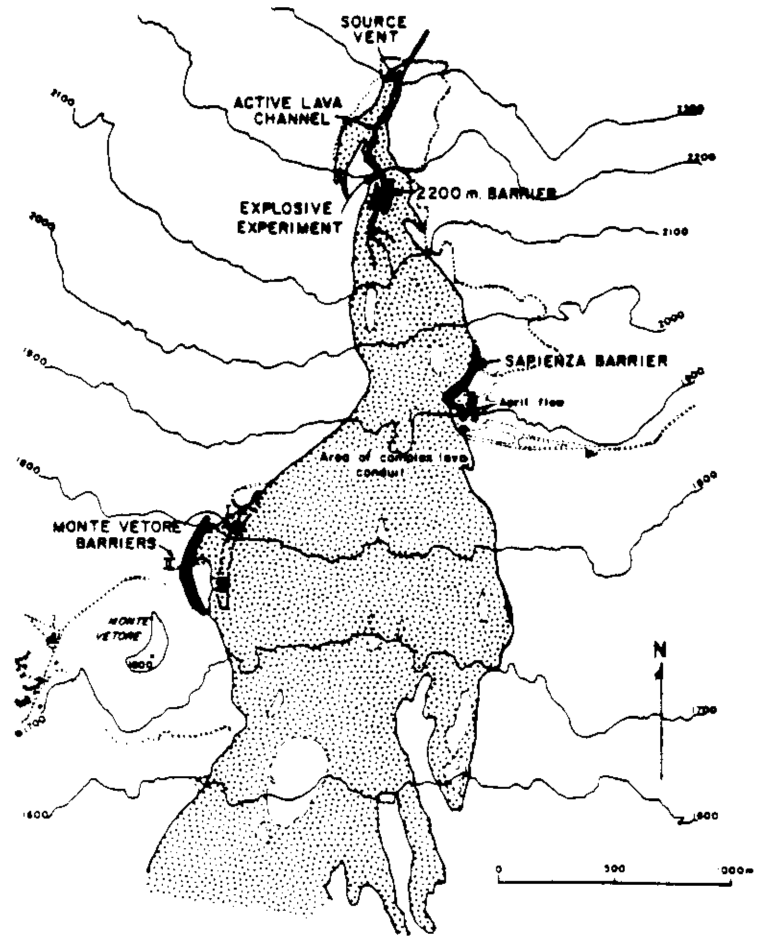
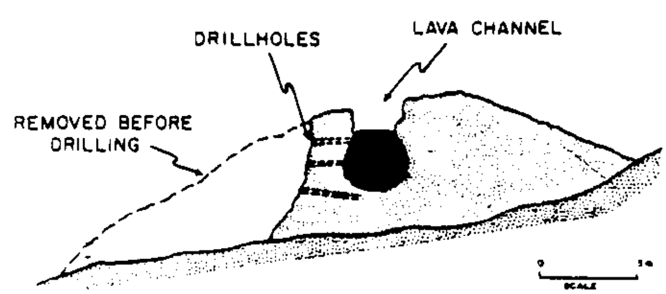


Figure 15. General areas of high (H), medium (M); and low (L) risk from surface ruptures. (Mullineaux and Peterson, 1974)



16a



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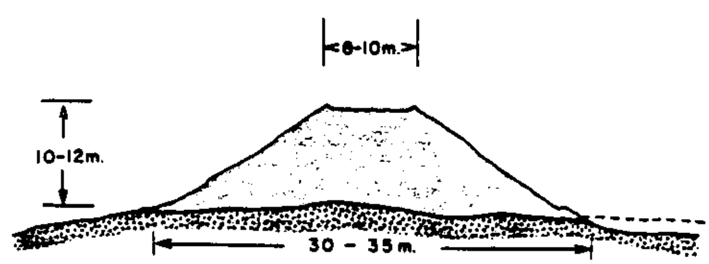

16c

Figure 16A. 1983 lava flow on Mt. Etna in Italy.
Figure 16B. Cross-section of explosives placement area.
Figure 16C. Typical barrier cross-section
(Figures from Lockwood, 1983)

REFERENCES

Capuano, Jr., L. E., 1983-84, Testimony before the Board of Land and Natural Resources regarding the Campbell Estate conservation district use application.

Crandell, D. R., 1983, Potential Hazards from Future Volcanic Eruptions on the Island of Mau, Hawaii, United States Geological Survey Misc. Investigation Series Map No. I-1442.

Helsey, C. E., 1983-84, Testimony before the Board of Land and Natural Resources regarding the Campbell Estate conservation district use application.

Holcomb, R. T., 1980, Kilauea Volcano, Hawaii: Chronology and Morphology of the Superficial Lava Flows, Dissertation submitted to Dept. of Geology, Stanford Univ.

Lockwood, J.P., 1983, Diversion of Lava Flows at Mt. Etna, Volcano Views, no. 15, p. 5.

Lorins, A. and L. H., 1983, The Fragility of Domestic Energy, The Atlantic Monthly, Nov. 1983, p. 118-126.

Macdonald, G. A., Abbott, A. T., and Peterson, F. L., 1983, Volcanoes in the Sea: The Geology of Hawaii, 2d ed., Honolulu, University of Hawaii Press.

Macdonald, G. A., 1962, The 1959 and 1960 Eruptions of Kilauea Volcano, Hawaii, and the Construction of Walls to Restrict the Spread of the Lava Flows, Hawaii Institute of Geophysics Contribution No. 42.

Moore, R. B., 1983-84, Testimony before the Board of Land and Natural Resources regarding the Campbell Estate conservation district use application.

Mullineaux, D. R., and Peterson, D. W., 1974, Volcanic Hazards on the Island of Hawaii, United States Geologial Survey open-file report 74-239.

Niimi, G., 1984, Evidence of Geothermal Potential in Kahaualea, Thermasource, Inc.

Niimi, G., 1983-84, Testimony before the Board of Land and Natural Resources regarding the Campbell Estate conservation district use application.

Peck, D. L., Thermal properties of basaltic magma: results and practical experience from study of Hawaiian lava lakes, Proceedings of U.S.-Japan Joint Science Seminar on Volcano Energy, Hilo, Hawaii.

Sean Report, March 1984, Mauna Loa Volcano, U.S.G.S. Hawaiian Volcano Observatory.

Stearns, H. T., not dated, The Geothermal Well Field in the Puna District, Hawaii, report prepared for the Hawaiian Electric Company.

True/Mid-Pacific Geothermal Venture, 1982, Revised Environmental Impact Statement for the Kahauale'a Geothermal Project, prepared by R. M. Towill Corp., Honolulu.

Tryggvason, E., 1979, Rifting of the Plate Boundary in North Iceland 1975-1978, Journal of Geophysical Research, Vol. 84, p. 3029.

Williams, R. S. and Moore, J. G., 1977, the Eruption on Heimaey, U.S. Geological Survey Publication.

GEOTHERMAL TECHNOLOGY

Circular C-108

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
September 1984

GEORGE R. ARIYOSHI
Governor

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PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which address each of the subzone designation factors. A brief description of geothermal technology emphasizing those aspects with possible environmental effects is provided in this publication.

This report was prepared by Joseph Kubacki, Energy Specialist, under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development, Department of Land and Natural Resources. The assitance of Dr. Donald M. Thomas, Geochemist with the Hawaii Institute of Geophysics, is acknowledged and appreciated.

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SUMMARY

In Hawaii, geothermal reservoirs are expected to occur 4,000-8,000 feet below sea level. Rotary drilling rigs likely to be used in Hawaii are rated for drilling to a maximum depth of about 16,000 feet. Holes may be drilled perpendicular to the ground surface or directional to almost any desired angle from ground surface. The local subsurface geology and the availability of well control techniques and blow-out prevention equipment minimizes the risk of well blow-outs. Approximately ten acres of cleared land may be needed to site the wells necessary for a 25 megawatt power plant. Drilling mud and cuttings may be disposed of at the drill site sump or can be removed if required. While in the production zone, return air is likely to contain hydrogen sulfide which can be abated by a caustic soda abatement system. After well completion, up to eight hours of unabated venting may be necessary to clear rock debris. Well casing intergrity is essential if usable water aquifers are to be protected. Steam piping from well-head to power plant may be placed about five feet above ground on saddles or may be buried for safety and aesthetics.

Before a power plant becomes operational the State Department of Health must issue permits regarding the quality of the air and fluids discharged from the plant. The proposed DOH regulations require a 98% H_2S removal and a maximum concentration of about 25 parts per billion H_2S at the property line. Abatement systems are available which can meet these standards, eg. the Stretford abatement system. Contingency abatement systems are likely to be designed into the power plant. The plume exiting the cooling tower should consist entirely of water vapor. The use drift eliminators in the cooling tower should prevent water droplets from exiting with the vapor. Liquid effluent should be piped into deep injection wells. If the silica content of the effluent is high, a silica dropout system may be utilized to prevent injection well plugging. The surface area for a 25 megawatt power plant may be about seven acres.

Roads and electric transmission lines may be constructed or upgraded to accomodate geothermal exploration, development, and production activities.

The County of Hawaii geothermal noise guidelines limit noise to 55 decibels by day and 45 decibils at night at nearby residences. Abatement technology exists to abate noise to acceptable levels.

GEOTHERMAL TECHNOLOGY

GEOTHERMAL WELLS

Drilling Depth

In Hawaii, geothermal reservoirs are expected to occur 4,000-8,000 feet below sea level. The rotary drilling rigs likely to be used in Hawaii are rated for drilling to a maximum depth of about 16,000 feet. Some mainland oil-rigs can drill to 22,000 feet but are not considered economical when applied to geothermal development here. The basic elements of a rotary drilling rig are shown in figure 1.

Directional Drilling

A geothermal rig can drill a hole perpendicular to the ground surface or directional holes to almost any desired angle from ground surface. A moderate curve in the drill route can also be achieved. Directional drilling can reduce both environmental and economic costs by allowing multiple holes to be drilled from one drill site. However the most economic and shortest route for a drill hole is usually straight and perpendicular to the surface.

Drill Hole Casing

Figure 2 depicts a typical well profile. The drilled hole has a 26-inch diameter for the first 250 feet, tapering to an eight inch diameter bottom hole in the production zone. The usual casing program includes a conductor pipe (surface to 250 feet), surface casing (surface to 2500 feet), intermediate casing hung from the end of the surface casing (2500 to 4000-6000 feet), and possibly a production liner hung from the end of the intermediate casing to bottom hole. All joints should be cemented and joined to ensure casing integrity into the production zone. Available well control techniques and blow-out prevention equipment can substantially reduce the risk of well blow-outs.

Drill Site Surface Area

A 2/1 ratio of good to bad wells is expected in a proven resource area. Once a successful well is drilled, six closely spaced wells (four expected successful) may be drilled within a radius of 2000 feet of the drill site. Two acres of land would be cleared for an exploratory hole. Approximately five acres of land would be cleared on a proven drill site. Four successful wells (three and spare) may be needed for a 12.5 megawatt (MW) plant. Generation capacity can vary from three to ten MW per well depending on the output rate and type (water or vapor dominated) of geothermal resource. The HGP-A test well is producing about three MW; however commercial wells are expected to have a larger capacity. Unsuccessful or expended wells would be abandoned unless used for injection of geothermal effluent.

Drilling Emissions and Effluents

Depending on geologic structure and capability of drilling equipment, either "drilling mud" or air will be used to remove cuttings and lubricate the drill bit. Drilling activities may use 2000 barrels of water per day per well. The mud and cuttings are disposed of at a drill site sump but can be removed to an approved disposal site if required. In the production zones, air drilling (instead of mud) may be used to avoid reduction of permeability in the production zone. While in the production zone, the return-air will contain cuttings and geothermal gases (most significant being H_2S). A caustic soda (NaOH) injection system and cyclone muffler can be used to abate hydrogen sulfide (H_2S), particulates, and noise during drilling (see figure 3). After completing the well, four to eight hours of unabated venting may be required to clear the hole of rock debris. Completed wells will be subjected to flow testing to determine reservoir characteristics. Emissions must meet Department of Health (DOH) standards. If the well is water dominated, a flash separator may be used at the well site to return brine to either a nearby percolation pond or reinjection well.

Injection Wells

One injection well may be needed for the three active wells which may be required to fuel a 12.5 MW plant. The number of injection wells will vary depending on the permeability of the injection well and the quantity of brine flowing from the production wells. The initial injection wells (specifically drilled for injection) are likely to be close to the plant to limit brine piping distance. Nonproducing or expended production holes may also be used for injection. Geothermal effluents will be injected into a geothermal aquifer having similar characteristics. Drill casing intergrity through overlying fresh water aquifers is essential if usable water supplies are to be protected. Injection wells are subject to standards and regulations of the State Department of Land and Natural Resources and Department of Health.

STEAM PIPING

The steam piping from well-head to plant is likely to be 16 to 22 inch diameter carbon-steel pipes. Piping may be placed four to six feet above ground-level on "saddles" which may be fortified to accomodate pahoehoe lava flows. Alternatively, piping may be buried for safety and aesthetics. The piping will have expansion joints which will allow for thermal expansion and some ground movement. Surface area needed for a pipeline corridor is discussed in "roads" section below.

GEOTHERMAL POWER PLANTS

Operation

Figure 4 depicts a simplified geothermal power generation system, emphasizing emissions and effluents. Before a plant becomes operational the Department of Health must issue permits regarding the quality of the air and fluids discharged from the plant. Components of this system are described below.

The characteristics of the geothermal fluid may vary from site to site. It may be liquid or vapor dominated. A vapor dominated system provides more steam for power generation per hole while reducing the hamount of brine which must be injected back into the ground. HGP-A is a water dominated system. Kapoho wells #1 and #2 have been reported to be vapor dominated.

As the geothermal fluid enters the power plant the steam and brine components are separated in the "separator". The compostion of the HGP-A brine is given in figure 5. Various heavy metal concentration such as arsenic, lead, and mercury are very low and should remain in the brine that is eventually reinjected. The steam phase leaving the separator consists of primarily water vapor and noncondensable gases. These gases as found at HGP-A are listed in figure 6. The two most significant noncondensable gases are H_2S and Radon 222. As described below, the level of H_2S can be almost completely abated. Outdoor concentration levels of emitted radon, if properly abated by dilution in the cooling tower, are lower than most indoor levels; since cement emits some radon in most buildings. Again, the composition of fluids and gases are likely to vary a bit with each reservoir.

The steam phase from the separator enters the turbine, turns the rotors, and exhausts into the condenser. Electricity is produced as the turbine spins the generator. The steam flow and resultant turbine-rotor turning is enhanced by the vacuum created in the condenser as the steam is condensed into liquid. This liquid (condensate) returns with the warm condenser cooling water to the cooling tower where it is cooled by evaporation. The size of the steam plume will vary with the size and efficiency of the plant, the cooling tower design, and the ambient weather characteristics.

Emission Abatement

The gas phase which exits the condenser consists primarily of the same noncondensable components which left the separator, most notably H_2S. An abatement system is utilized at this point to reduce the H_2S content to an acceptable level (see figure 4). A report recently prepared for the U.S. Environmental Protection Agency, Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, analyzes most available H_2S abatement systems. These include the iron catalyst primary system; the iron catalyst secondary system; the hydrogen peroxide, caustic, iron catalyst (HPCC) primary system; burner-scrubber system; and the Stretford system. The report recommends the Stretford system as the primary on-line abatement system. This system can remove over 99% of the H_2S contained in the noncondensable gases. By-products of the Stretford system include marketable elemental sulfur and sludge which requires disposal.

A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement systems can be utilized in the event the plant is "down" for maintenance or emergency. If maintenance is required on either the turbine or generator, the geothermal steam can be routed directly into the condenser utilizing the primary abatement systems. Since the turbine does not dissipate any heat or energy in the bypass mode, the cooling system must be over-designed to accomodate the extra heat during "turbine bypass". If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal (see figure 4). In emergencies, well throtting may be accomplished by manual valve turndown or automatic valve control. Throtting must be slow (at least 15 minutes) and can reduce flow to a fraction of the well's maximum flow rate. The degree of throtting possible will depend upon the characteristics of each well. However, there is a danger that the additional stress with increased pressure could damage the well-bore, casing, or well-head equipment. If a geothermal development has more than one power plant, the wells could be moderately throtted and diverted to an operating plant. If all the above contingency abatement options are not available, a geothermal well may have to be free vented through a silencer without H_2S abatement until the required maintenance is completed or such time as the well can be shut-in completely.

The abated gases, condensate, and warm water are circulated through the cooling tower. Cooled water from the cooling tower is recirculated through the condenser; any excess water (blowdown) is piped into an injection well. It is expected that a wet, mechanical draft, cooling tower will be applied to geothermal development. Warm water enters the tower near the top, while a fan forces air through slats designed to maximize the surface area of the falling warm water. Use of drift eliminators significantly reduces the chance that any water droplets will exit with the steam plume. This falling water also scrubs any particulates from the gas exiting the abatement system. At "The Geysers" geothermal development in California, small amounts of boron from the condensate has been emitted with cooling tower drift (small water droplets entrained in the the steam plume) having some adverse effects on nearby vegetation. Based on the characteristics of the HGP-A reservoir fluids and the emission abatement which will be required by the DOH, cooling tower emissions from Hawaii's geothermal resources should not be toxic to flora and fauna in the vicinity of the geothermal power plant. Data available from the HGP-A indicates that the plume from the cooling tower should consist entirely of water vapor. The proposed DOH regulations require 98% H_2S abatement and a concentration of no greater than 25 parts per billion H_2S at the property line of a development.

In addition to cooling tower blowdown, brine leaving the separator will be piped into the injection well. If the rate of silica deposition in the brine is high, a silica-dropout system will be utilized between the steam-brine separator and the injection well. Otherwise, silica deposition within the injection well might cause it to become plugged. The silica deposits will be removed periodically and disposed of in an acceptable manner.

Plant Site Surface Area

The surface area required for a power plant varies with its megawatt output. Figures 8 through 13 depict the dimensions of the 12.5 and 55 MW capacity power plants. By using these units in tandem a 25 MW or 110 MW facility can be constructed without increasing the land area of the plant site significantly. Generally, a 12.5 or 25 MW plant will have structure dimensions of 90 feet x 40 feet x 54 feet high (per 12.5 MW unit) sited on a surface area of about 7 acres. A 55 or 110 MW plant will have structure dimensions of 350 feet x 80 feet x 75 feet high (per 55 MW unit) sited on a surface area of about 15 acres.

ROADS

Roads must be constructed to accomodate geothermal exploration, development, and production activities. Their placement should avoid volcanic hazards as much as possible. The extent of road building activities at a particular location will be influenced by the existing road infrastructure. Figure 14 depicts the design of access, well field, and power line roads. Road designs must be submitted to the counties for construction permit approval. Approximate road dimensions are given below.

	Width	Height	Description
Initial access	20'	-	One lane with shoulders.
Main access with transmission lines	78'	76'*	Two lanes, shoulders, & transmission lines on both sides.
Well field road	30'	4-6'**	One lane, shoulders, dual pipeline corridor on one side.

ELECTRIC TRANSMISSION LINES

Construction of a new transmission line corridor is required to connect the geothermal power plant to the existing power grid. By referring to figure 15, which depicts the existing power grid on the island of Hawaii, it appears that the need for new power line corridors will be minimal. However, existing lines may need to be upgraded. Figure 16 shows the clearance needed for 69 kilovolt (68' wide-67' high) and 138 kilovolt (78' wide-76' high) power line corridors. Dual lines will be used to assure reliability.

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*electric transmission line poles

**steam piping height

NOISE LEVELS AND ABATEMENT

During the initial phases of field development, persons in the immediate vicinty of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site. High noise levels are produced during well drilling, production testing, and bleeding before connection to the generator. Drill rig noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise. Above noise levels apply to the immediate vicinity within 100 feet of the source.

The County of Hawaii geothermal noise level guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted.

The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. A chart is provided in figure 17 which describes the noise levels from geothermal operations at "The Geysers" in California. Noise will vary with weather conditions and topography. Technology exists which should abate noise to acceptable levels.

REFERENCES

Geothermal Energy for Hawaii, 1981, Department of Planning and Economic Development Publication, Honolulu.

Geothermal Power Development in Hawaii, 1982, DPED Publication, Honolulu.

Kestin, J., (ed.), 1980, Sourcebook on the Production of Electricity from Geothermal Energy, U.S. Dept. of Energy Publications, Contract No. Ey-76-S-4051.A002.

Molenkamp, C.R., 1979, Cooling Tower Drift, U.S. Dept. of Energy by Lawrence Livermore Laboratory under contract #W-74050Eng-48.

Ratto, J.B., 1983, Blowouts: Causes and Results, Cudd Pressure Control, Inc.

Report Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii, 1984, Dames & Moore, Honolulu, EPA contract #68-02-3508.

Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June 1982, A True/Mid-Pacific Geothermal Venture in Coordination with Campbell Estate.

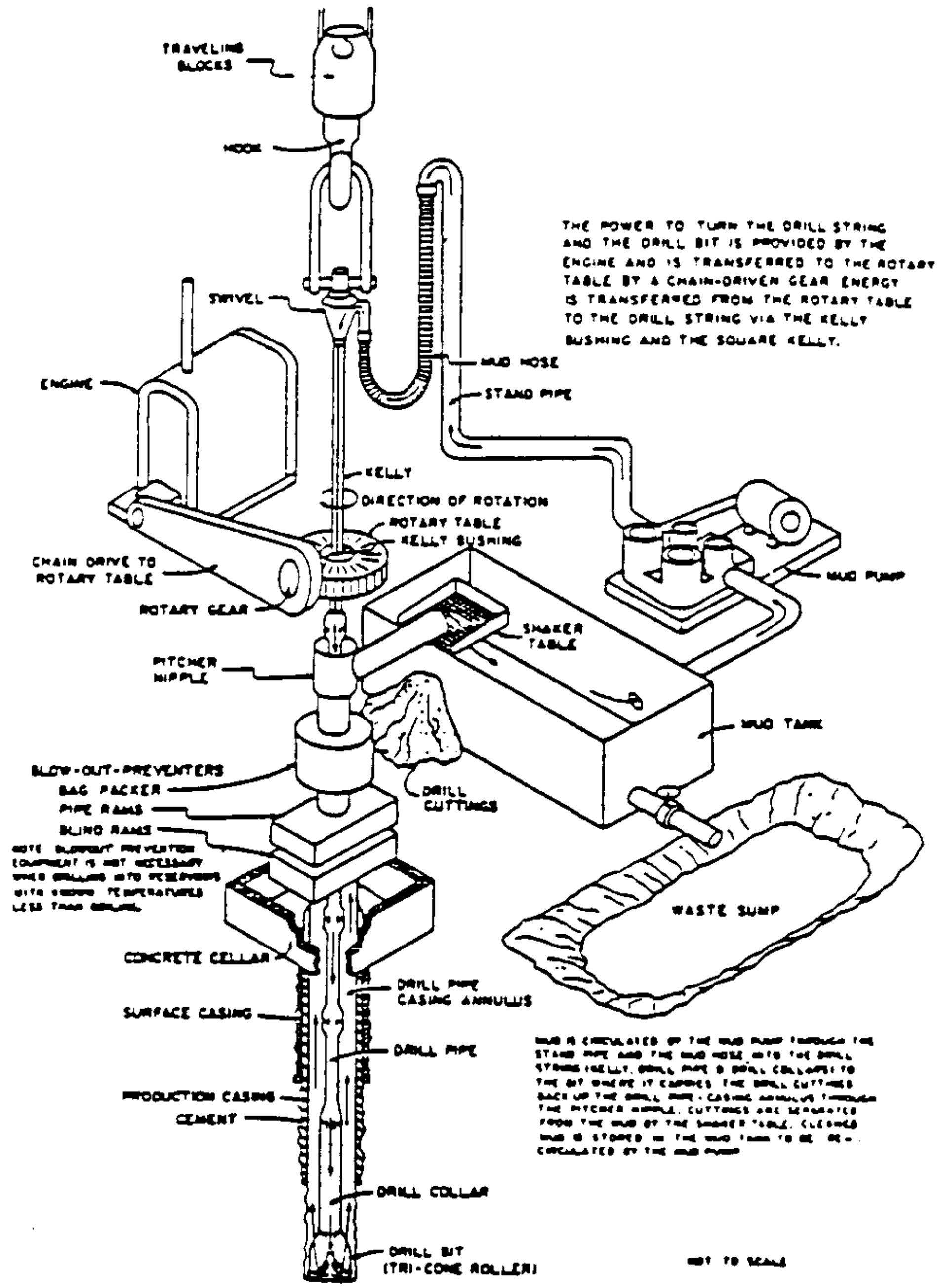


Figure 1. Basic Elements of a Rotary Drilling Rig.
(Source: Geothermal Power Development in Hawaii, 1982)

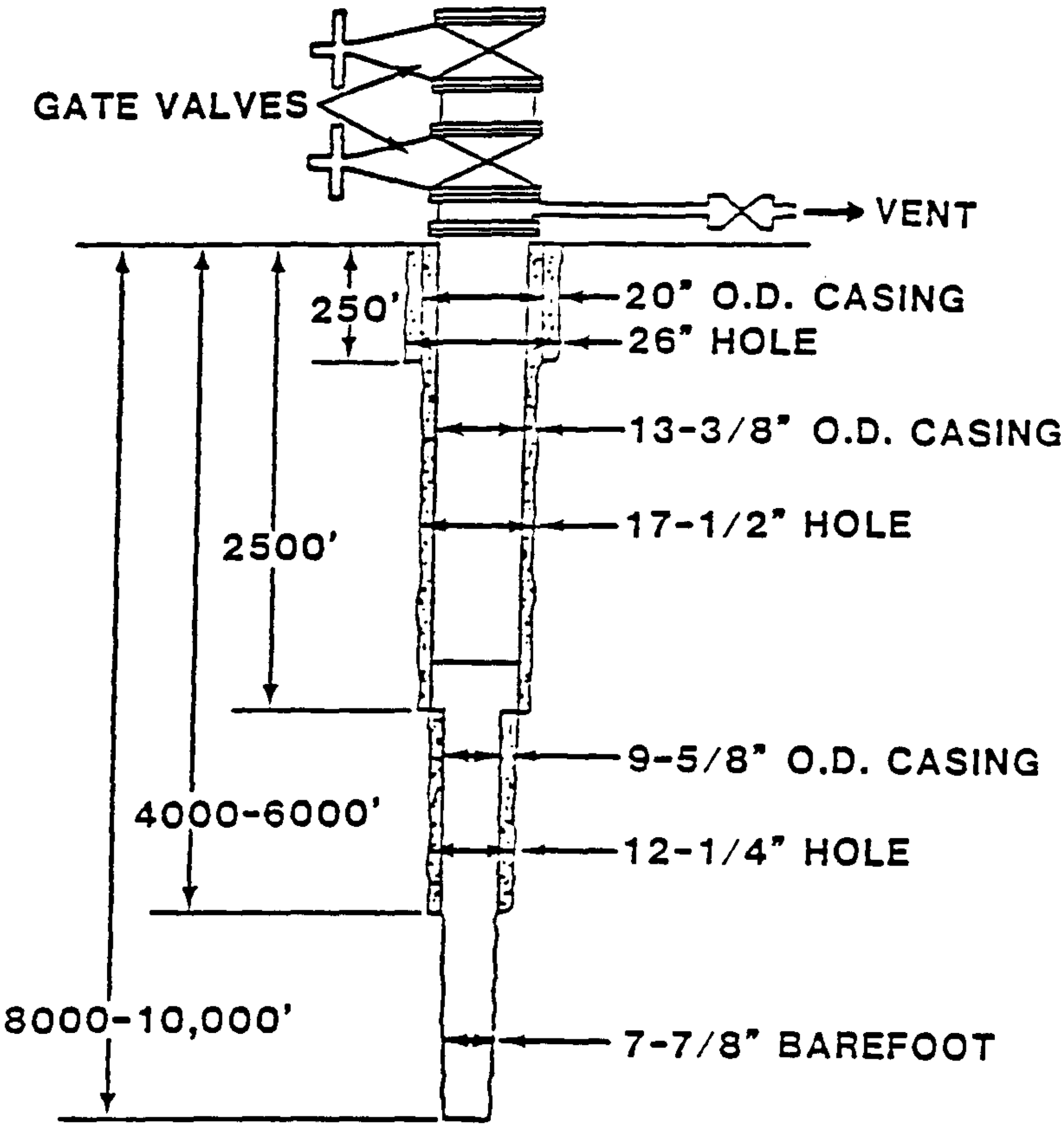


Figure 2. Typical Well Profile.
(Source: Kahaualea EIS, 1982)

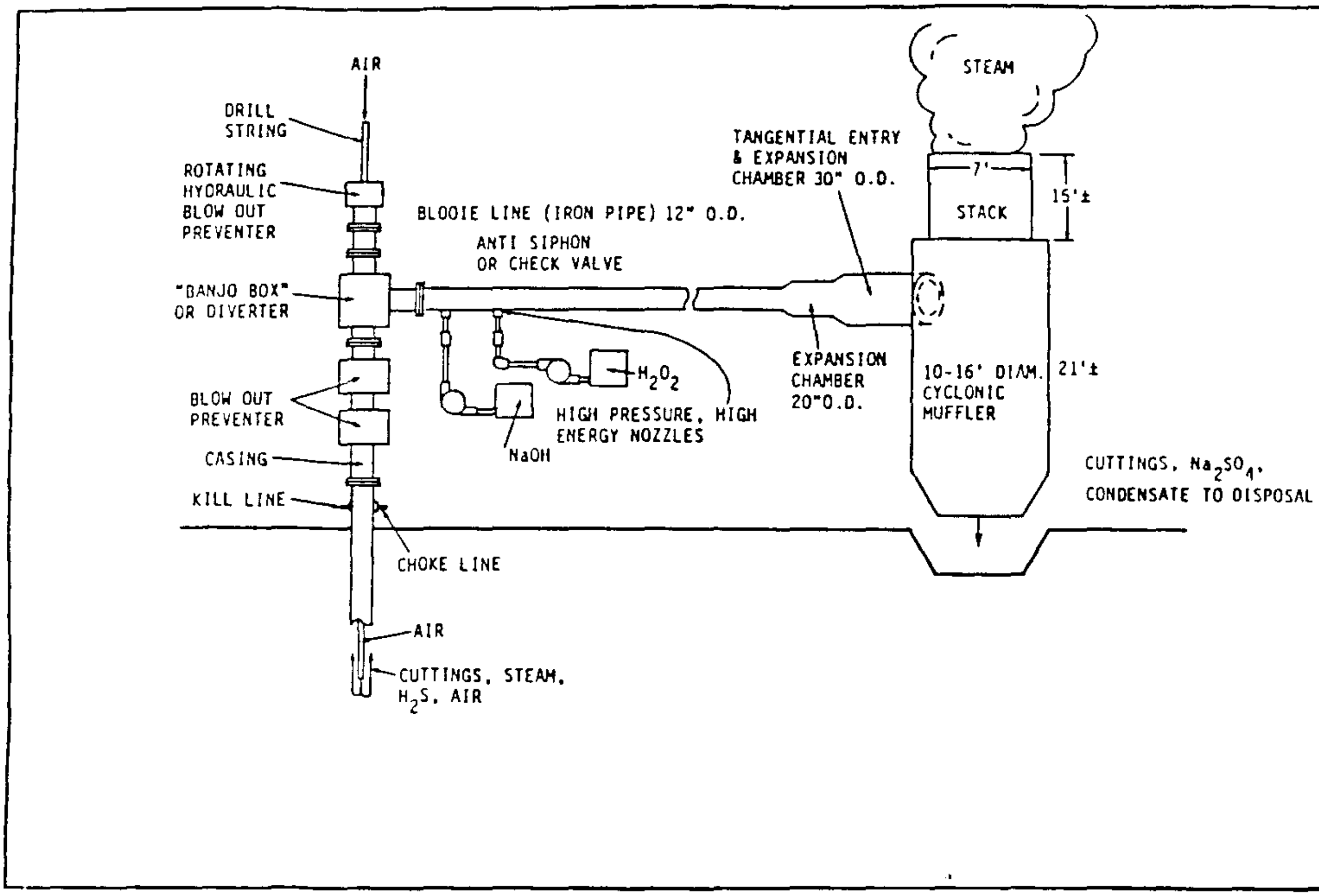


Figure 3. H_2S Removal During Well Drilling. (Source: Dames & Moore, 1984)

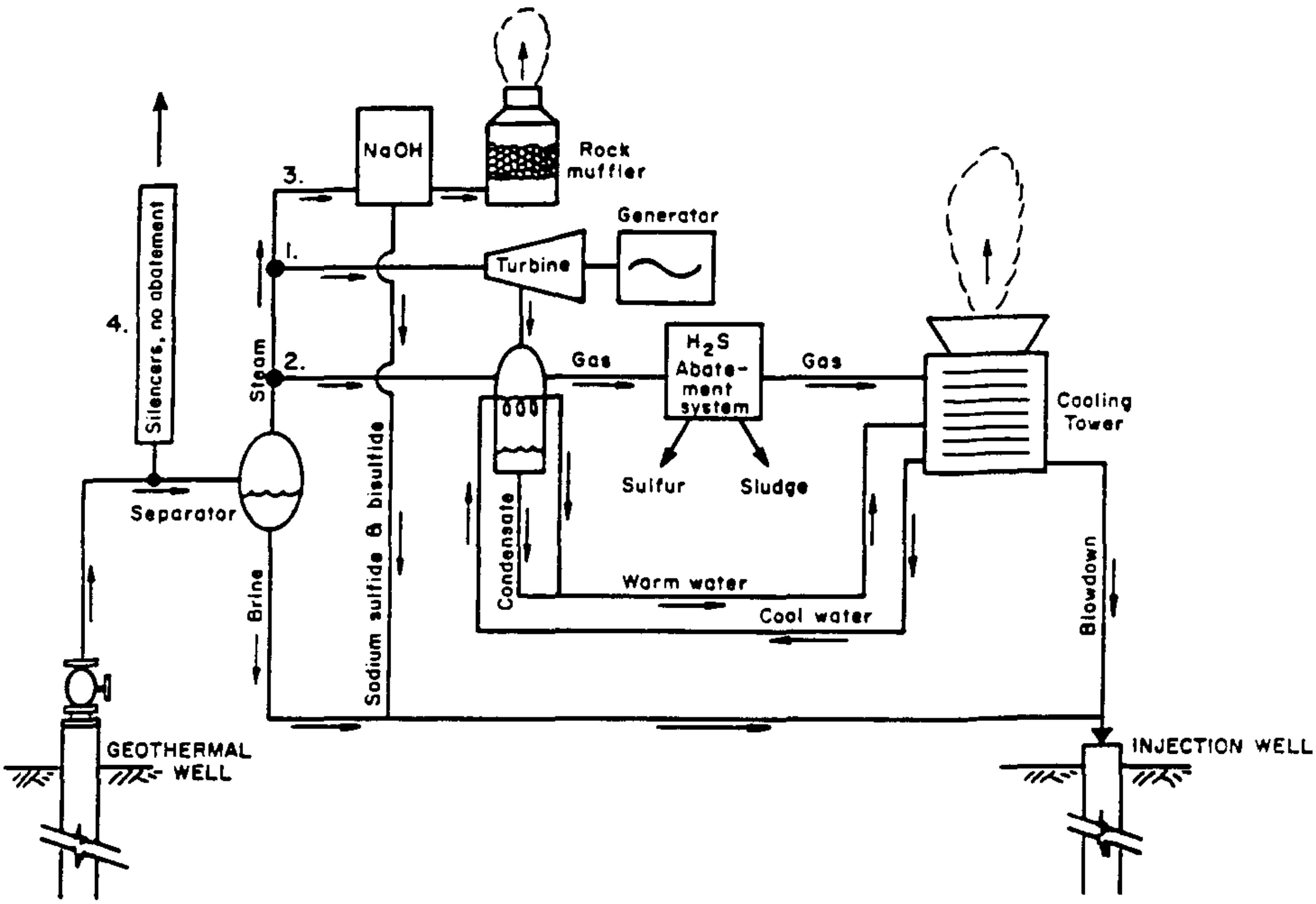


Figure 4. Hydrogen Sulfide Abatement During Power Plant Operation.

1) using primary abatement system (sulfur and sludge are byproducts of the Stretford abatement system);
2) using "turbine bypass" gas still abated through primary abatement system;
3) using contingency caustic (NaOH) abatement system;
4) unabated flow in emergency situations.

Element	Concentration, ppmw
Arsenic	0.01 - 0.001[b]
Barium	2
Boron	2
Calcium	218
Cadmium	<1.0[c]
Carbonate	75
Chloride	7200
Cobalt	0.014
Copper	<0.004
Gold	<0.00004
Iron	0.02
Lead	<1[c]
Lithium	0.034
Magnesium	0.131
Manganese	0.034
Mercury	<0.001
Molybdenum	0.067
Nickel	<0.02
Niobium	<0.4
pH	7.4[d]
Phosphorous	0.2
Platinum	<0.006
Potassium	600
Silica	800
Silver	<0.02
Sodium	3700
Strontium	2.0
Sulfate	50
Sulfide	17
Tantalum	<0.001
Thallium	<1[c]
Tin	<0.2
Titanium	0.006
Uranium	0.16
Vanadium	0.016
Zinc	0.012

[a] Liquid samples taken from cyclone separator (Thomas, 1983a).
[b] Rough estimate based on preliminary analysis, Thomas, 1983b.
[c] Thomas, 1982b. 'Less than' signs indicate detection limit of analyzer.
[d] Before atmospheric flashing, Thomas, 1982a.

Figure 5. Particulate Composition of HGP-A Brine. (Source: Dames & Moore, 1984)

Gas	Concentration (ppmw in steam)	
	Geysers[a] (dry steam)	HGP-A[b] (separated steam)
CO_2	3260	1200
H_2S	222	900
NH_3	194	0
CH_4, C_2H_6	202	NR[c]
N_2	52	125
H_2	56	56
He	NR	0.5
Total (ppmw)	3985	2237
Total (wt%)	0.40	0.22
Rd^{222} nCi/lb steam	6.1	1.5

[a] Source: NCPA, 1981; Squire and Robinson, 1981.
[b] Source: Thomas, 1983a.
[c] NR - not reported.

Figure 6. Geothermal Noncondensable Contents. (Source: Dames & Moore, 1984)

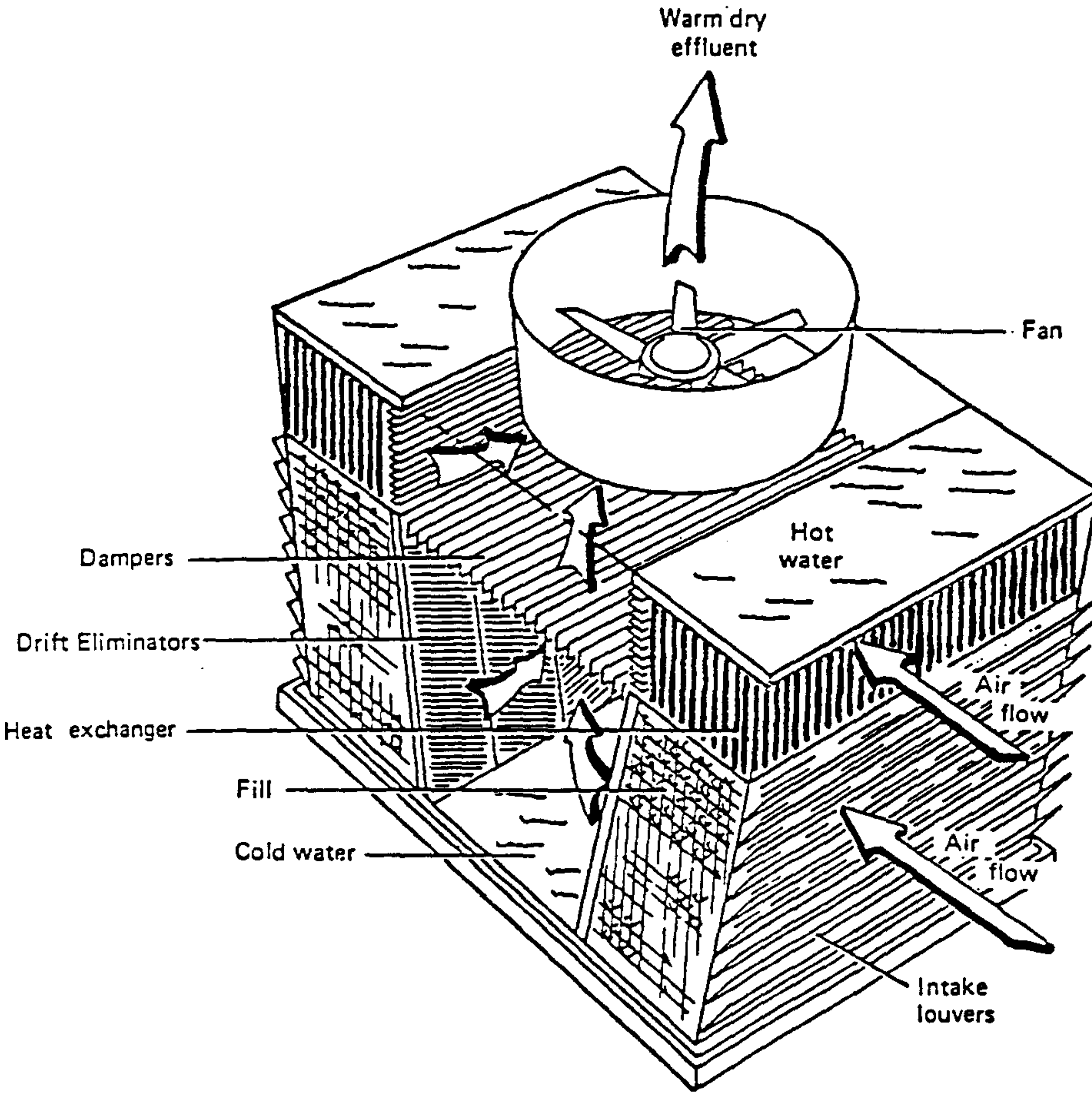


Figure 7. Cross-flow Mechanical Draft Cooling Tower. (Source: Molenkamp, 1979)

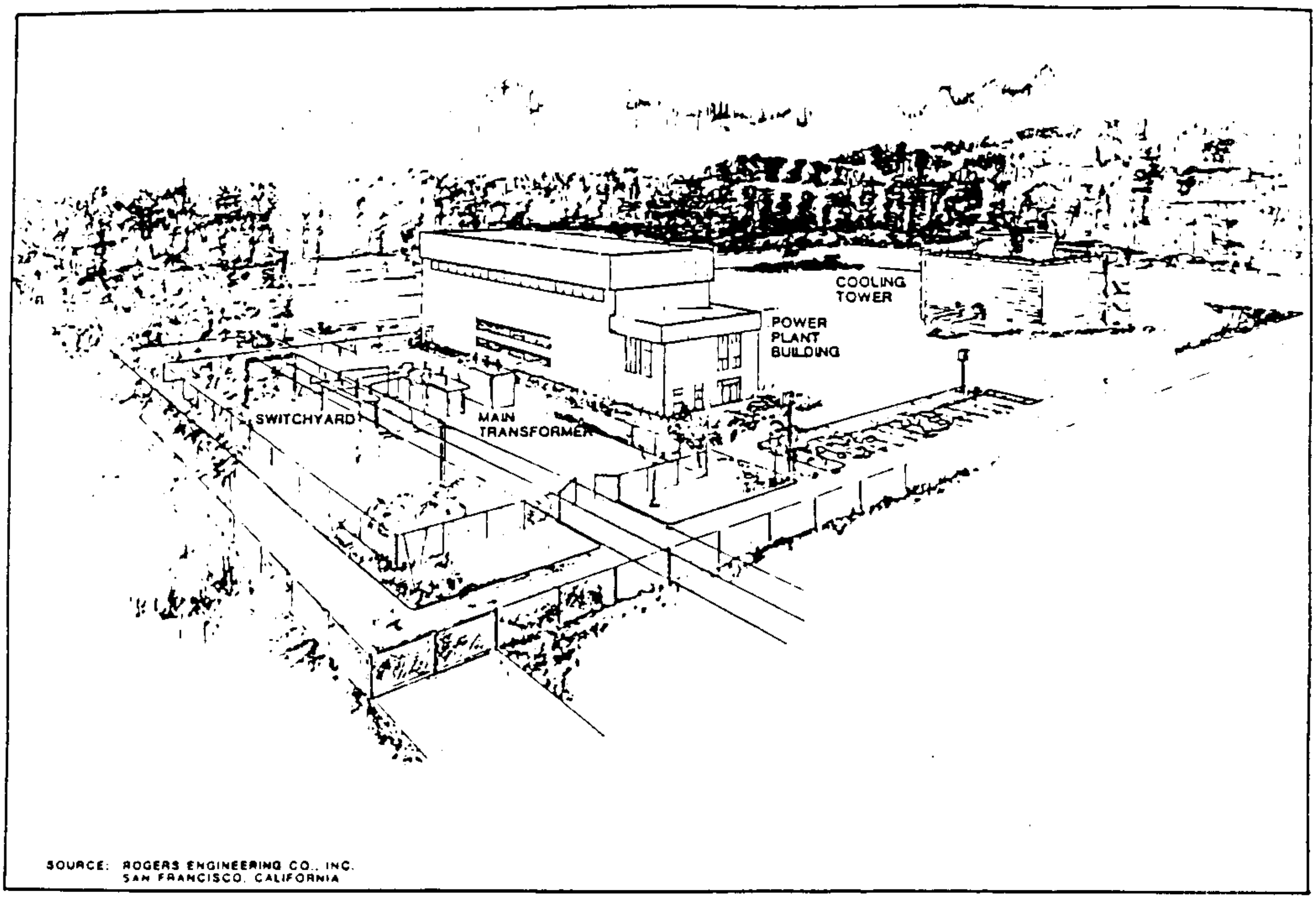
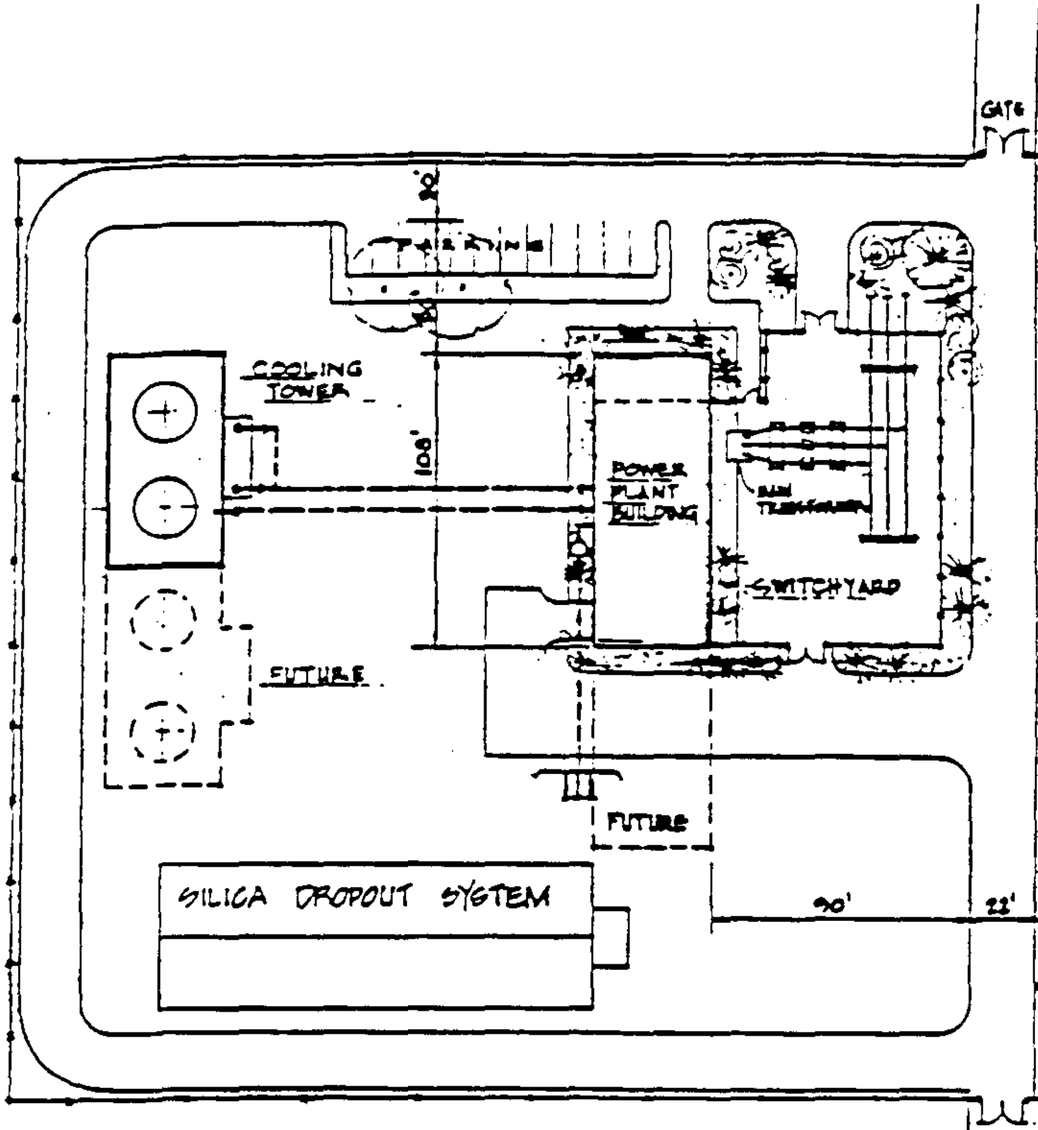


Figure 8. Perspective - Initial 12.5 MWe Power Plant.



SOURCE: ROGERS ENGINEERING CO., INC.
SAN FRANCISCO, CALIFORNIA

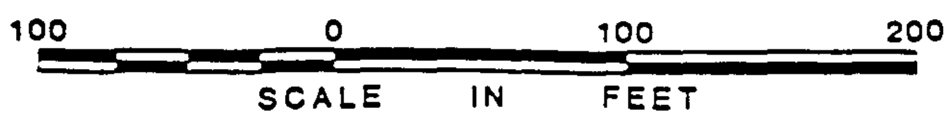


Figure 9. Site Plan - Initial 12.5 MWe Power Plant.
(With Expansion to 25 MWe)

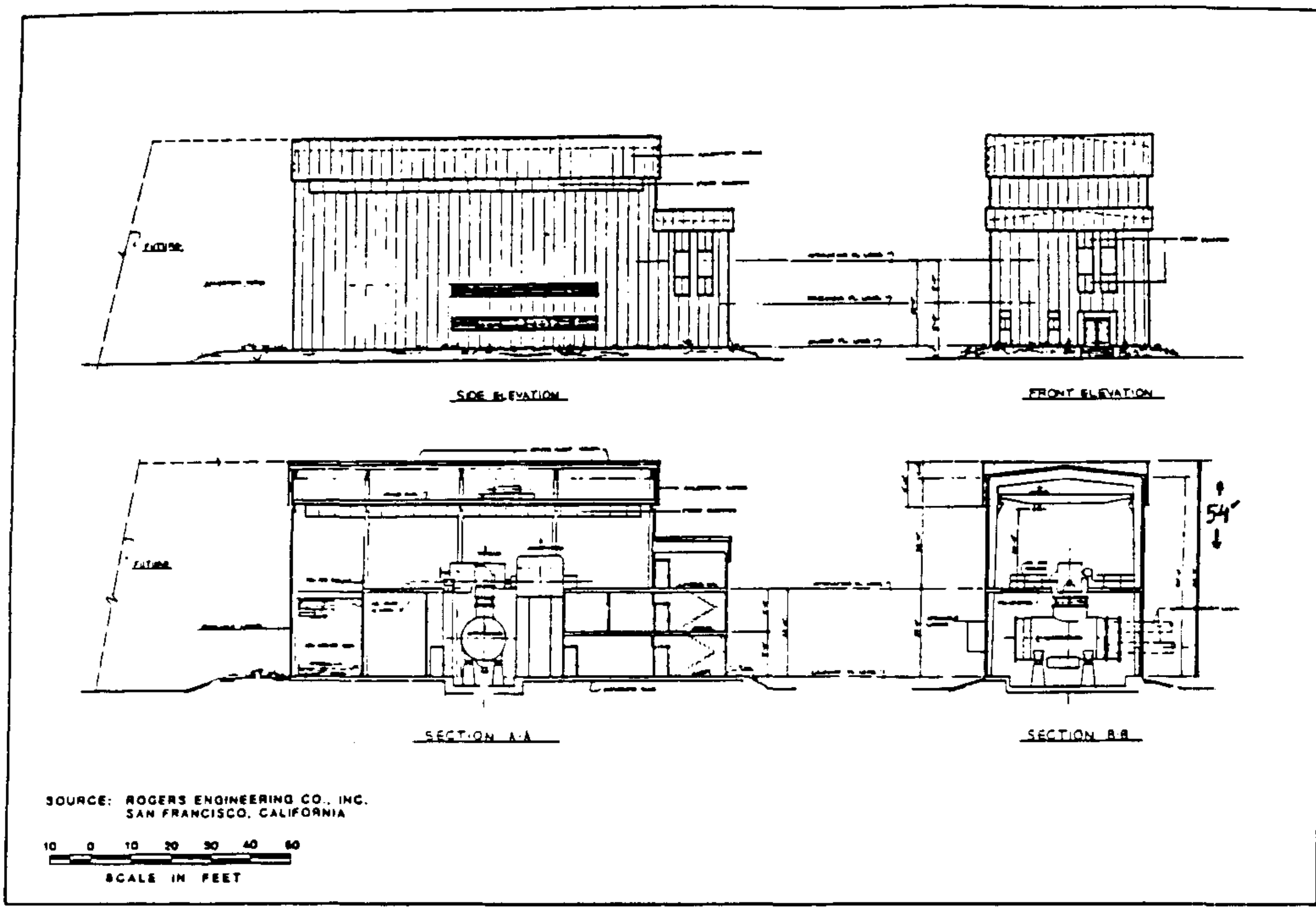


Figure 10. Elevations and Sections - Initial 12.5 MWe Power Plant.

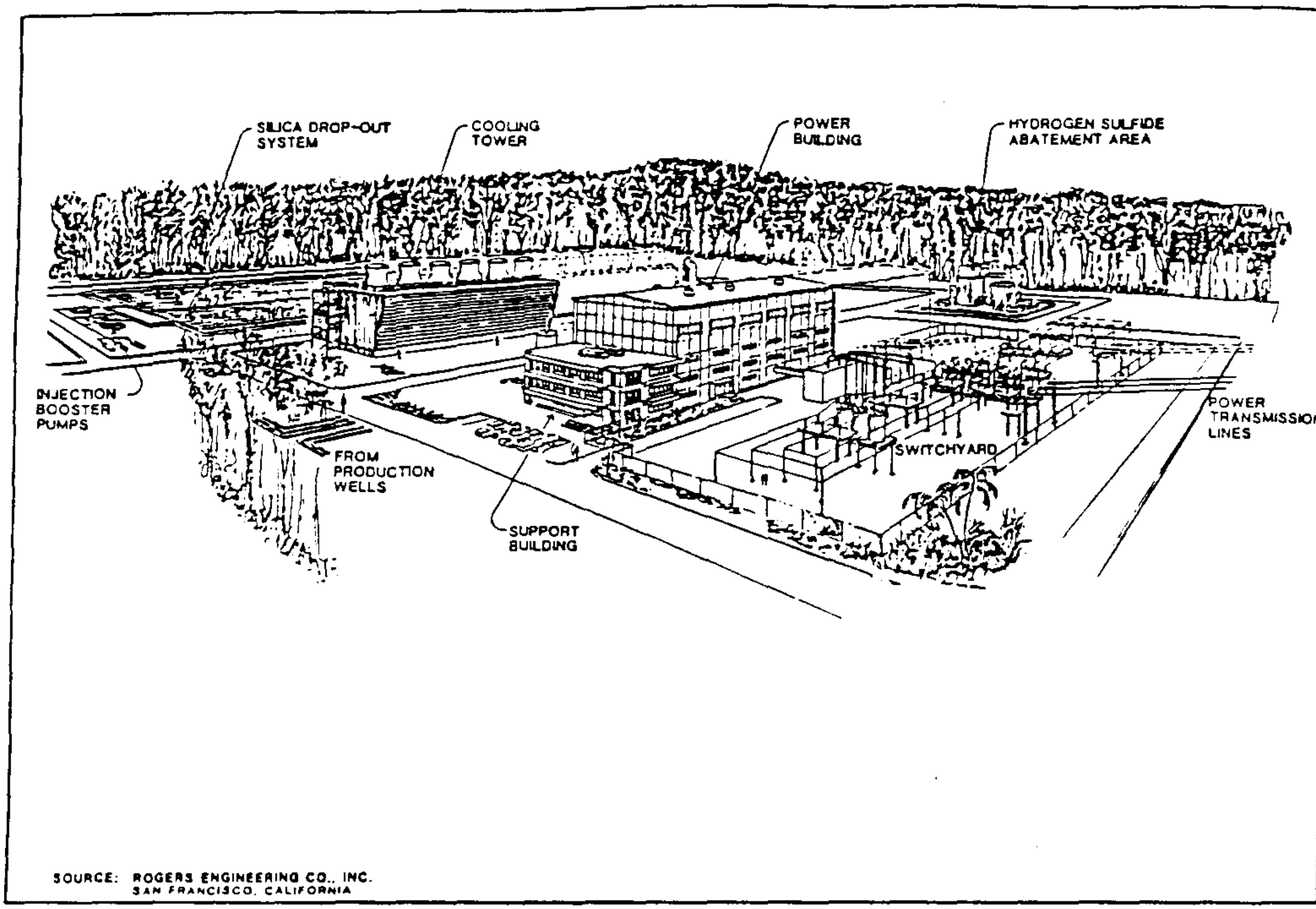


Figure 11. Perspective - 55 MWe Power Plant.
(With Expansion to 110 MWe)

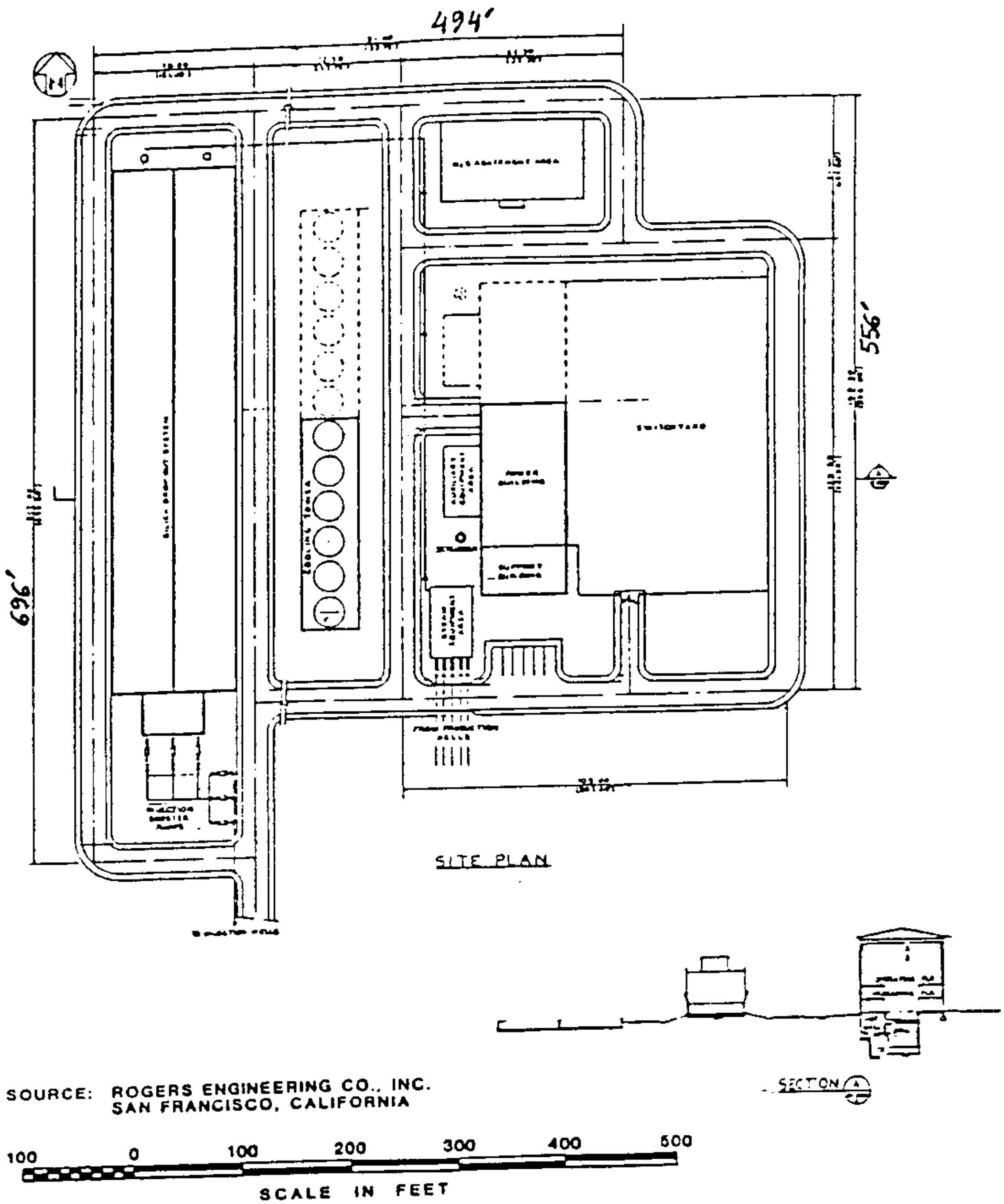
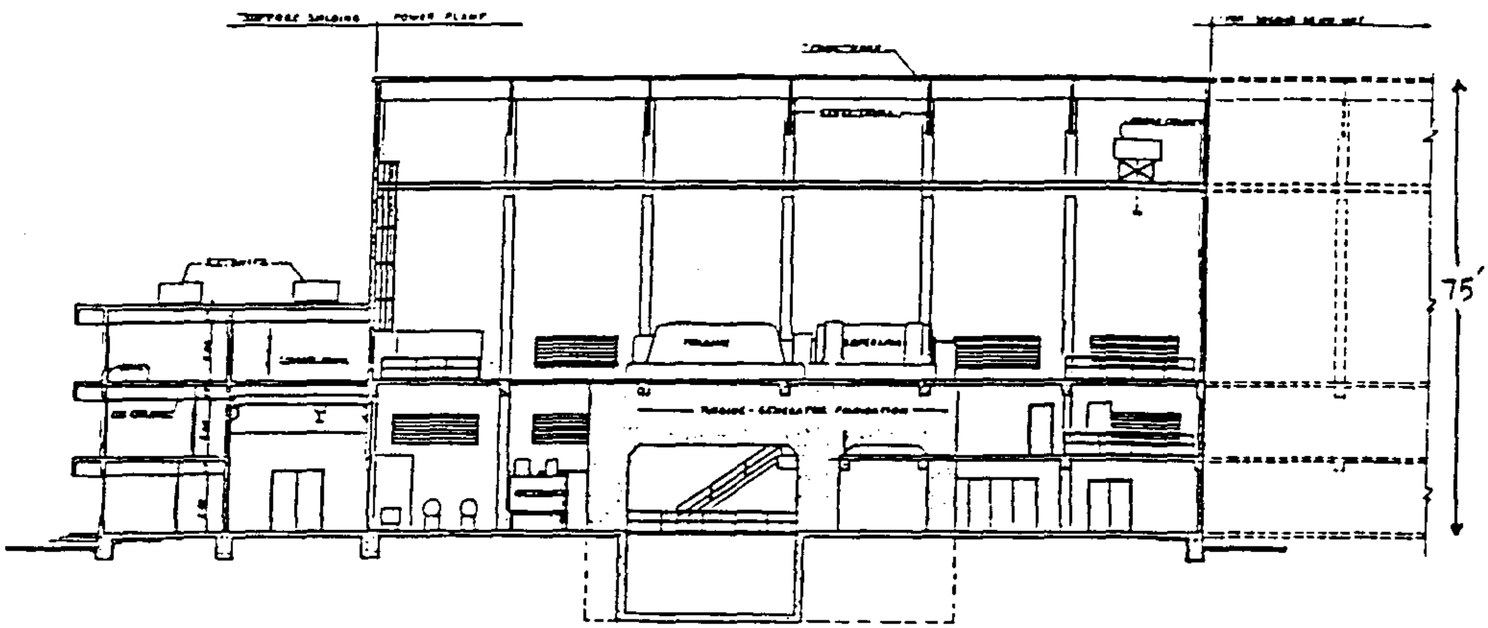


Figure 12. Site Plan and Section, 55 MWe Power Plant. (With Expansion to 110 MWe)



TRANSVERSE SECTION 'A-A'

SOURCE: ROGERS ENGINEERING CO., INC.
SAN FRANCISCO, CALIFORNIA

10 0 10 20 30 40 50
SCALE IN FEET

Figure 13. Transverse Section, 55 MWe Power Plant. (With Expansion to 110 MWe)

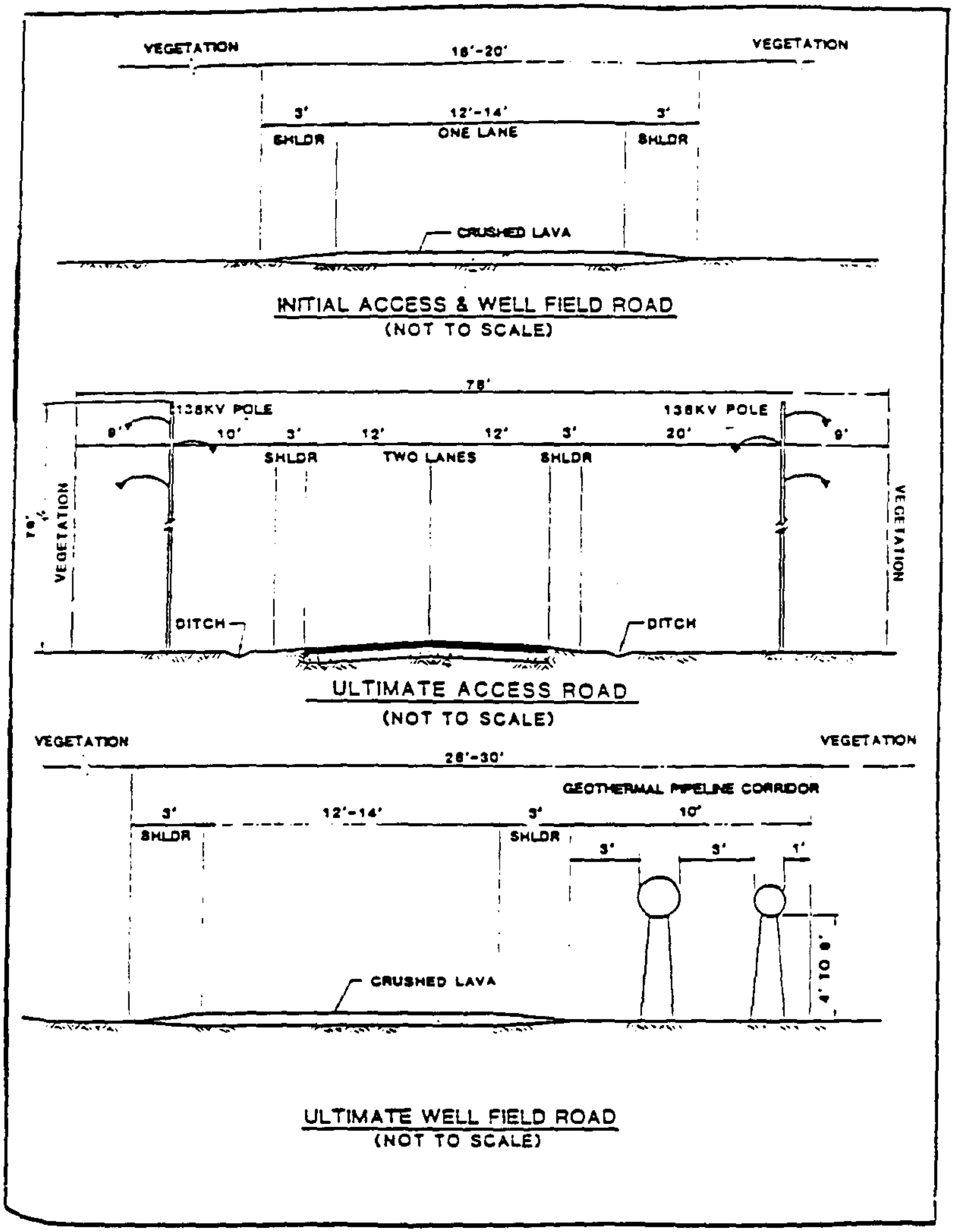


Figure 14. Road Design.
(Source: Kahaualea EIS, 1982)

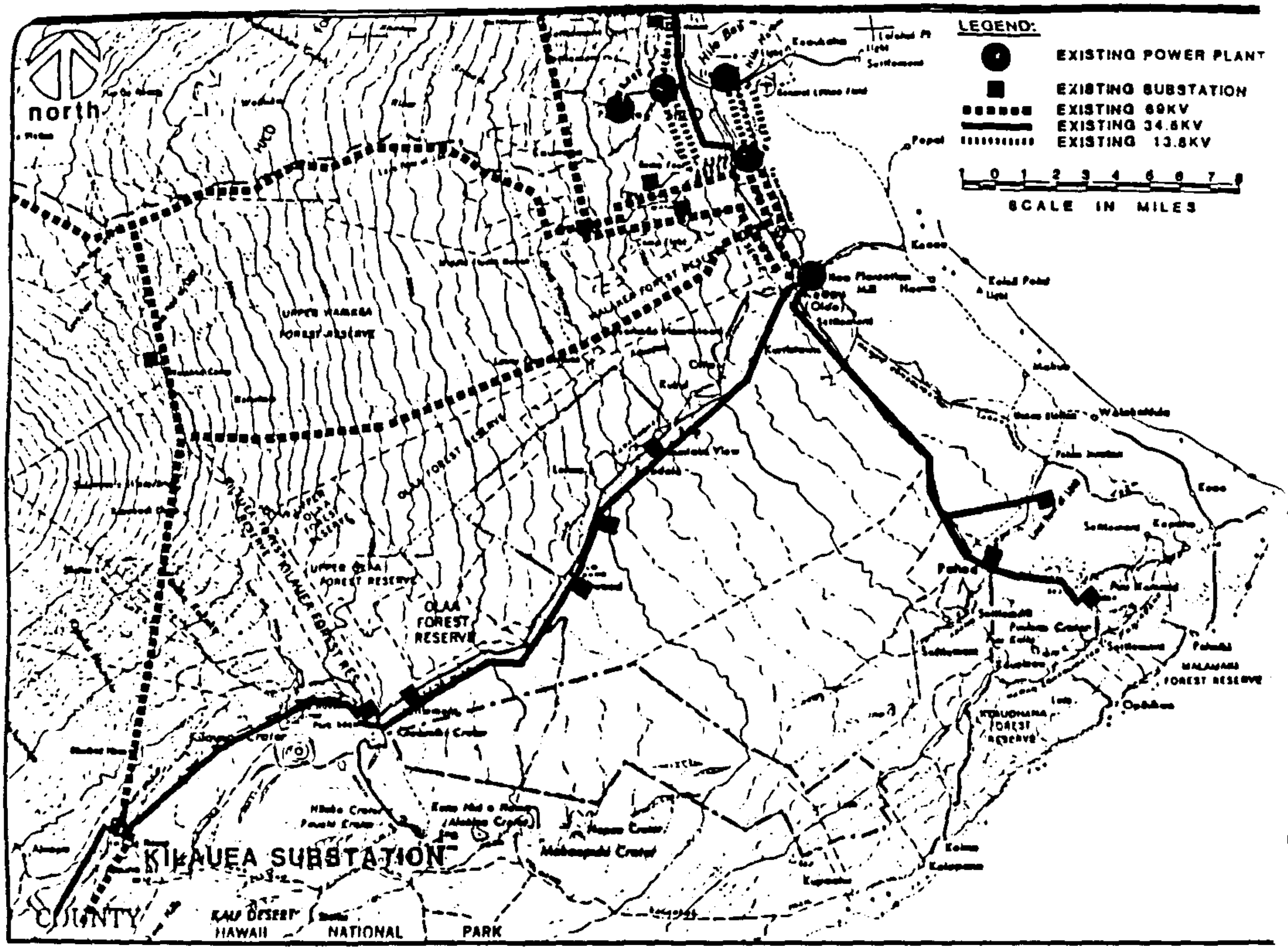
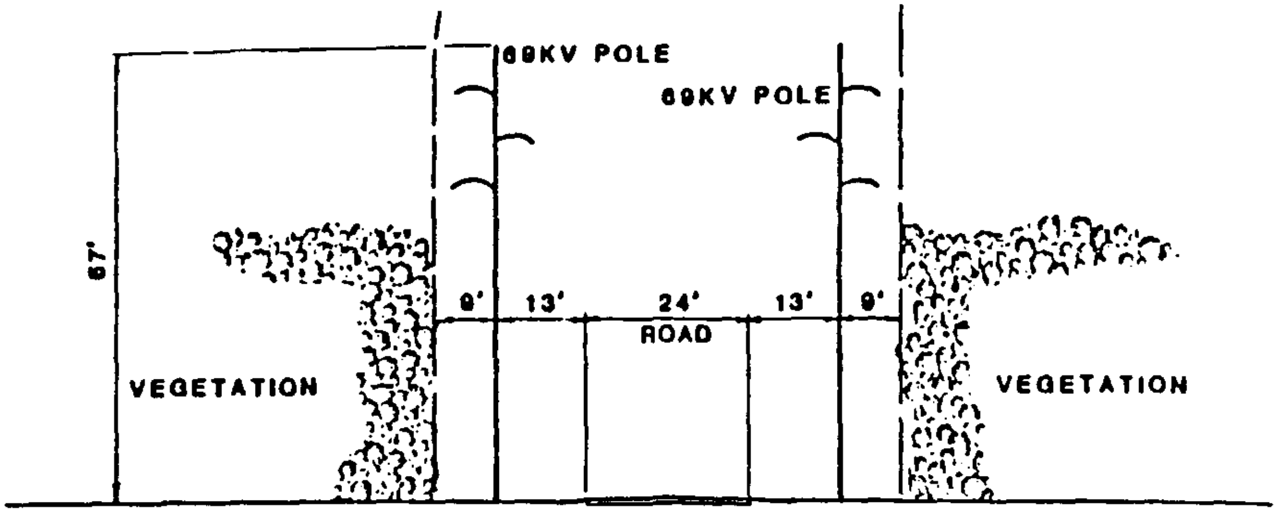
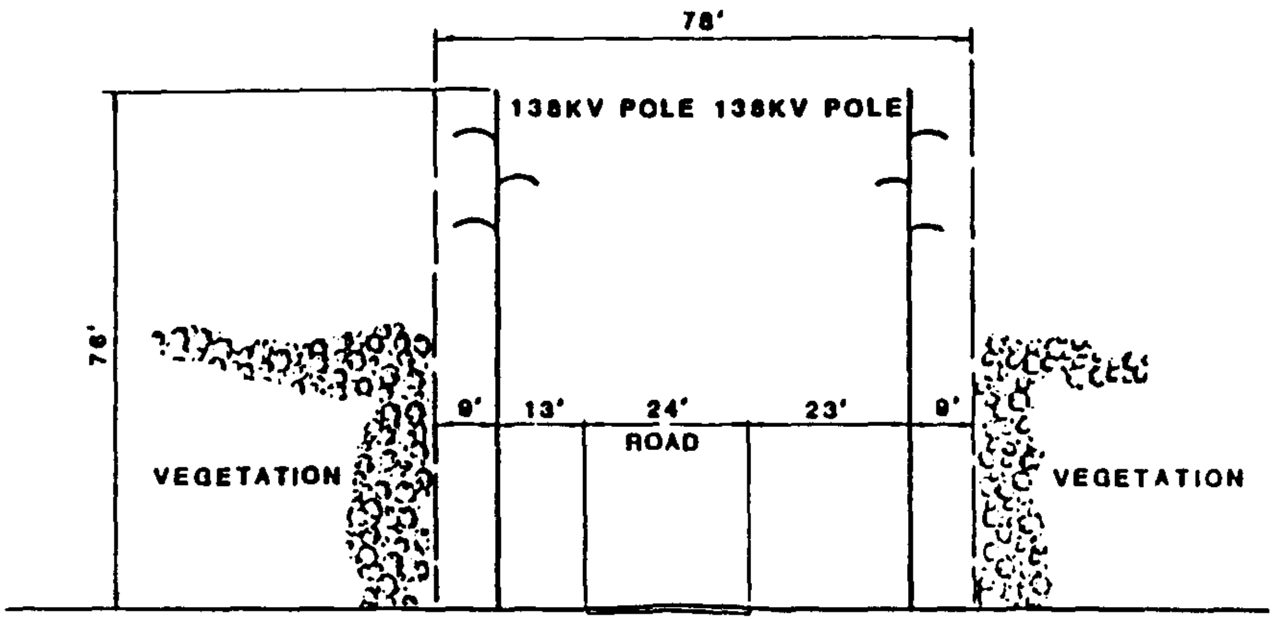


Figure 15. HELCO Power Transmission System.



69KV POWER TRANSMISSION LINE CORRIDOR
(DETAIL "A")



138KV POWER TRANSMISSION LINE CORRIDOR
(DETAIL "B")

SCALE: 1" : 30'

Figure 16. Power Transmission Line Corridors.
(Source: HECO)

Operation	Duration	dBA at 100'
WELL DRILLING		
Mud Drilling	60 days/well	69-74
Air Drilling, Including	30 days/well	
blow line		108
blow line w/air sampler		83
blow line w/air sampler & water injection		73
Well Cleaning; Open Well	3-6 days	112
Well Testing; Open Wells	14 days	112
Rock Muffler		77
Well Bleeding Before Connection to Generator	Variable	
open hole		60
rock-filled ditch		39
blowouts	Variable (infrequent)	112
CONSTRUCTION		
Operation of Construc. Machinery (Trucks, Bulldozers, etc.)	1-2 yrs.	64-84
PLANT OPERATION	20-30 Years	
Steam Line Vent (Muffled)	Intermittent	90
Jet Gas Ejector	Continuous	
unattenuated (old design)		97
with acoustical insulation		64
Steam Line Separator	Continuous	68
Steam Line Breaks	Brief, Infrequent	94
Cooling Tower	Continuous	60-70
Turbine-Generator Bldg.	Continuous	

Figure 17. Noise Levels of Geothermal Operations at The Geysers. (Source: Kahaualea EIS, 1982)

PROCEEDINGS

SEMINAR ON CONFLICT RESOLUTION FOR ENERGY SITING AND LAND USE

February 18, 1986 · Honolulu, Hawaii

Co-sponsored by
Department of Planning and Economic Development
The State Judiciary
Program on Conflict Resolution, University of Hawaii

This report has been cataloged as follows:

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Co-sponsored by the Dept. of Planning & Economic Development, the State Judiciary, and the Program on Conflict Resolution, University of Hawaii.

1. Hawaii-energy industries. 2. Industries, Location of-Hawaii. 3. Land use-Hawaii. 4. Conflict management-Hawaii. 5. Environmental mediation-Hawaii.
HC110.E5P76

SEMINAR ON
CONFLICT RESOLUTION FOR ENERGY SITING AND LAND USE

Tuesday, February 18, 1986, 8:00 a.m. to 1:30 p.m.
Sheraton-Waikiki Hotel, Honolulu, Hawaii

PROGRAM

8:00 a.m. **REGISTRATION**

8:30 a.m. **INTRODUCTION**
Kent M. Keith, Director, Department of Planning and Economic Development

8:35 a.m. **"Hawaii's Need for Alternatives"**
The Honorable George R. Ariyoshi, Governor, State of Hawaii

8:45 a.m. **"Resolving Public Resource Disputes: The National Picture"**
David L. O'Connor, Executive Director Commonwealth of Massachusetts Mediation Service

9:30 a.m. **"Patterns of Resource Disputes in Hawaii"**
Tom Dinell, Director, Conflict Resolution Program, University of Hawaii

10:15 a.m. **COFFEE BREAK**

10:30 a.m. **RESPONSE PANEL:** Moderator, **Peter Adler,** Director, Program on Alternative Dispute Resolution, State Judiciary

Community Perspectives: Kenneth Kupchak, Attorney, Damon, Key, Char & Bocken
Joann Yukimura, Member, Kauai County Council

Developer Perspectives: Rod Moss, Executive Vice President, Mid-Pacific Geothermal, Inc.
George St. John, President, Amfac Energy Inc.

Government Perspectives: Hideto Kono, Chairman, Public Utilities Commission
John Whalen, Director, Dept, of Land Utilization, City and County of Honolulu

Practitioner Perspective: John Knox, President, Community Resources, Inc.
David Matteson, Account Executive, Communications Pacific

11:30 a.m. **QUESTION & ANSWER PERIOD**

12:00 Noon **LUNCHEON**

12:45 p.m. **LUNCHEON ADDRESS—The Honorable Herman T.F. Lum,** Chief Justice, State of Hawaii

1:30 p.m. **ADJOURNMENT**

Co-sponsored by
Department of Planning and Economic Development
The State Judiciary
Program on Conflict Resolution, University of Hawaii

INTRODUCTION

Kent M. Keith, Director
Department of Planning and Economic Development
State of Hawaii

Good morning, ladies and gentlemen, and welcome to this seminar on Conflict Resolution for Energy Siting and Land Use.

The purpose of today's seminar is to examine alternative methods for resolving the differences of opinion and possible disputes which all too often arise in our daily affairs, in our families, communities, businesses and government.

Litigation, one method for resolving disputes, is often counterproductive. I am sure we all can think of land use projects where the parties involved were very quick to litigate their disputes. Battle lines become drawn, positions become hardened, those affected become "opponents" and "proponents," negatives are emphasized, large amounts of money are spent, and often months and years of delay are involved. Results are often unpredictable. Rather than working together towards a mutually desired end, parties become winners and losers -- often remaining embittered. Afterwards, cooperation is difficult -- not only did parties disagree on immediate issues but they may find it increasingly difficult to deal with each other in resolving future disputes.

The siting of energy facilities has given rise to several disputes in recent years. As we all know, land in Hawaii is a limited resource. Groups of citizens are often in disagreement as to how our land should be used. All too often they seek to maximize special interests, rather than trying to maximize total net benefits to all those affected by the dispute.

Geothermal development provides a case in point. In 1982, about six years after our HGP-A experimental well discovered a viable geothermal resource, a geothermal developer applied for a permit to explore and develop geothermal power in the Kilauea Upper East Rift area. A dispute arose between some members of the local community and the developer regarding the size and siting of this energy project. The traditional methods of conflict resolution have resulted in numerous administrative and court proceedings at considerable cost and with a great deal of time and effort spent by concerned parties. Today, four costly years after the dispute started, numerous court appeals are still pending, no exploration has started, and those involved in the dispute do not seem closer to resolving it. In short, a tremendous amount of human and financial resources seem to have been expended, and the issue is still undecided. Is there a better way to pursue our goals? Is there a way to bring people together? It is my impression that those who have been called opponents of geothermal development usually favor development if it proceeds in a responsible manner. Also, the developers have shown their good faith and flexibility by offering alternative development plans. Almost everyone agrees that geothermal electricity and direct use applications offer many benefits to Hawaii. There is much common ground here, yet progress seems so elusive.

This is only one example. Unfortunately, there are many more. The siting of H-Power, Honolulu's municipal-waste-to-energy project, was a problem which took five years and much effort to resolve. The proposed OTEC plant at Kahe Point, still faces some community resistance despite many environmental studies and informational meetings. And there are other examples.

Our State government is deeply concerned with alleviating disputes over energy siting and land use. This concern has been exemplified by our Governor. Governor Ariyoshi has devoted considerable time and effort to solving problems before positions have hardened to the point where litigation begins. We are honored to have him here with us today, as our opening speaker. Would you please join me in welcoming our Governor, the Honorable George R. Ariyoshi.

HAWAII'S NEED FOR ALTERNATIVES

The Honorable George R. Ariyoshi
Governor
State of Hawaii

Good morning. I'm pleased to have this opportunity to speak on a subject that is very important to me.

Let me begin by saying that I believe there are some things in our community that should happen and some that shouldn't. In terms of economic development, we're talking about doing things to strengthen our economic base. There is a need to plan, to build our economic base, to create jobs. But let me also suggest to you that while we must consider these needs, we must also be sure that we don't destroy Hawaii. Hawaii is a very fragile place; there are limits to what we can do, limits on the kinds of things that can be accomplished in this community. Decisions on providing for economic development and preserving open space are very important to our future, we must be sure that we make those decisions on a well-planned, well-thought-out basis.

Having said that, it is my firm belief that those projects that we feel are important to our community, those projects that must be completed, must be done expeditiously. They cannot be delayed. Projects that take four or five years to happen -- if they need to be done, there is no reason they should be taking that much time. We must keep in mind the fact that if we take a lot more time than we need to complete a project, its cost becomes very, very high and the consumer ends up paying for it. It's not the landowner, not the person who develops the energy project who bears the costs of the delay -- it is the consumer, those who purchase a property, the end-users of the land, the end-users of the energy. They are the ones who will bear the additional costs resulting from delays. And so, it is essential for us, once a decision is made and we have determined that a certain kind of project is important, that the project move ahead expeditiously.

In our community, there are those who honestly feel that some projects should not be implemented. I think we need to sit down and resolve these differences so we can reach a consensus, some agreement, on what should or should not take place in our community. There are some, on the other hand, who feel that the way to block everything is to delay. They hope that a long delay will result in such prohibitive and exorbitant costs that those who are involved in the creation of the project will at some point say, "I give up," and pull out. That is not an acceptable approach.

A project for resort development proposed for the small Island of Molokai has been delayed for a long time because of the opposition of certain community groups. Very recently, I had a group of Molokai residents come to see me. They wanted to have more economic development and more jobs for Molokai. They told me that the great majority of the people on Molokai wanted more jobs, that many were on welfare. They wanted to work, they wanted to bring home paychecks, they wanted to take care of their families, they wanted to live with dignity, they wanted the little extras that a job provided that welfare did not. These were men and women who wanted to work. One fellow told me that he had been unemployed for three years and this is the first time that he has been unemployed for that long. He wanted to work so that he could send his daughter back to college. She had been in college, but he had to ask her to come home because there were no prospects of his getting a job right away. He was making a plea for something to be done so that the people of Molokai would have some jobs.

I looked at that development project and gave it a great deal of thought. I decided that it was most important to bring the opposing parties together to see whether they could resolve some of their differences. I asked the Lt. Governor to be involved, and he has been meeting with them now for the past week and a half, and will be having additional meetings this week. It is my hope that he will be successful in his efforts.

This leads me to today's seminar. It is very important for our people to find alternatives other than those which are now being used to resolve conflict. We should be able to find a way in which we can decide whether a project should be "go" or "no go." If it is "go," we need to bring the parties together and make it possible for these projects to proceed. In the area of energy, we must find alternative sources of energy. If we don't do this in the long run, and I'm really talking about the long run, we will at some point be without the finite energy resources that we now have. Hawaii must play a leading role in finding renewable energy resources that will provide cheap, efficient energy on a long-term basis. When I say "cheap," it may not be immediately, but it will be at some point in the future and it will be a reliable, dependable source that will be with us forever. We have to look at all the resources that we have, and we have to find ways in which we can make it happen. I feel very strongly about the need for us to proceed this way. For us to have projects that are delayed four or five years with no end in sight is not acceptable. We need to find some way in which we can make it possible for these things to happen.

So today's seminar, where all of you are trying to find a way to bring about the resolution of some of the conflicts that exist, is a very important effort. I commend you for your presence here; I hope that you will be able to come up with ideas that will make it possible for us to look at the problems and for us to be able to resolve them in a little better way. There have been all kinds of suggestions made -- mediation, arbitration, people coming together and just having a great deal of dialogue. Whatever they may be, it is very important for us to consider them.

Finally, in the existing process, if a dispute is not settled, it ultimately ends up in court. I am totally dissatisfied with the current way in which things are resolved in the courts. It is taking too long. There are great delays. I think we must find a more expeditious way in which the final decision will be made. It is my hope that you will give consideration to all ways in which the judicial process can be speeded up, the ways in which the judicial decisions can be made expeditiously, so that we can have a decision one way or another. I do not believe that it is to the benefit of any of us that we end up paying much more than we should be for a project that should be taking place or should have taken place more quickly.

I know that you all have different points of view and different ideas about how some of these things can be worked out. I think we need to hear all of the ideas, lay them out on the table, review them, and narrow down the alternatives to get some positive recommendations.

Thank you.

RESOLVING PUBLIC RESOURCES DISPUTES: THE NATIONAL PICTURE

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Let me begin my remarks by citing an article well-known to mediators, written in 1970 by Lon Fuller, a professor at the University of Southern California, on "The Form and Function of Mediation." He opens by noting that mediators often proceed to make a point through indirection. With stories and observations that appear unrelated to the topic at hand, they seem to be able to help the truth find its way out.

One story I cannot overlook concerns a now famous mediation attempt that occurred some years ago when the students in Iran had taken over the American Embassy and held a large number of Americans hostage. The process had gone on for quite a long time and you can remember the tremendous frustration and paralysis that plagued our President and the whole nation concerning that very troubling situation. There were many groups trying to help the parties involved begin a dialogue with one another. Among them, most credibly, perhaps, was the United Nations. Various overtures were made and finally an opportunity developed whereby the Secretary General, Kurt Waldheim, was given an invitation to visit Iran and to speak with President Khomeini and the students to see what he could do to understand their point of view and try to work out a settlement of the dispute.

Upon his arrival at the airport there were many news reporters and media people asking him what he was planning to do, what he would say and so forth. Since he did not speak Farsi, his response in English was, "I am here to try to mediate a compromise." This sounds like a perfectly diplomatic and careful thing to say, structured to put no one in a poor position or ill at ease. Unfortunately, there are ways in which English terms, such as "mediator" and "compromise," when translated into Farsi, take on unintended meanings. In fact, the way his remarks were rendered on national television was "I've come to meddle in your affairs and cause you to lose your virginity."

As you can imagine that didn't go over very well, particularly with the students and their supporters. When the Secretary General got into his limousine and tried to drive across town, his car was stoned and he was unable to get out. Eventually, he had to return to the airport and fly out of the country. A promising opportunity for mediation was stopped right at the outset. It strikes me one lesson in this is that someone from "out-of-town" should be careful about the things he says. I wouldn't want you to think I have come here to meddle in your affairs or to cause you to lose your virginity.

Let me turn to another story about someone who landed in trouble by traveling far and negotiating without much forethought. There was a fellow, I'm told, who had spent years as a counterfeiter in Virginia. He had a terrific printing press and used to print five dollar bills by the batch. He lived very well, but as he grew older, his technique and some of his attention to detail lapsed and all of a sudden he discovered one day that he had produced a huge bag full of fifteen dollar bills. Well, he knew he wasn't going to be able to use those bills so he took the bag and dumped it in the corner and got things back on line. He rigged up the machinery, put in new ink, and off he went printing five dollar bills again, and all went fine. But eventually, he grew older and tired and stopped printing bills.

One day he was about to leave on a fishing trip to the far reaches of Maine, and found himself behind schedule and without enough money. He thought, "What am I going to do here? The charge card is packed to the limit; I don't have any five dollar bills. I'm out of ink and the printing press isn't really working." Then he had a bright idea. "I'll take those fifteen dollar bills. I ought to be able to pass those off in Maine." So, off he went and was travelling through Maine and sure enough his car broke down. There was a problem with the engine that he couldn't figure out and so he finally gave up and decided to start walking in hopes he could get help and something to eat.

He walked and walked and finally came upon a little store off to the side of the road. It was really a makeshift, ramshackle place but it did have gas pumps so it gave him some hope that there might be help there for his car. He went in and spoke to a fellow behind the counter who had sort of a sleepy look about him. The counterfeiter said "I have a problem with my car and I wonder if you could help me. I'm in need of something to eat and I could use some help with the motor and I'm also a little short on money. I just have a fifteen dollar bill here. Could you possibly give me some change?" Well, the old storekeeper sort of shuffled around for a minute and he looked in the cash register and thought about it. Finally, he looked up and said, "Well, I think we might be able to do something for you here. How would you like that change? Five threes or a seven and an eight?"

That story reminds us that it is easy to underestimate the people that you're dealing with in negotiations, to underestimate their tenacity, their insight, their cleverness and perhaps even the legitimacy of their point of view. It also strikes me that this story offers a warning to those of us who wonder about the best way to negotiate. We wonder whether our approach to negotiation ought to be to get the most we possibly can regardless of the effect this has on the other side, or to pay attention to the quality of the process and respect the integrity of those with whom we negotiate. The story reminds me of the old adage: "what goes around, comes around"; that the way we negotiate encourages other people to think about the way they negotiate. Eventually, our own approach may come back around and be visited upon us. So, paying attention to how we negotiate, how we resolve conflicts, is an important thing to do. In the end, it benefits everyone.

Those who have written about dispute resolution have shown how infrequently litigation and arbitration are actually used to resolve disputes. They find the vast majority of disputes are resolved primarily by the people involved in those cases, through some form of negotiation with one another. I assume that all of you in your work negotiate often and know a great deal about negotiation. However, most of you, like me, probably grew up developing your negotiation skills by trial and error and by inheriting certain ideas and assumptions and myths from your parents, teachers and mentors about how to negotiate.

Yet, in the last five to ten years in the United States there has been an explosion in research, thinking and new ideas about negotiation and dispute resolution. In a sense, many of the assumptions that we've all inherited for decades are being questioned and rethought and a new understanding of them is under development.

One of the first questions about negotiation considered by these researchers is, when should one negotiate? The response to this question is largely determined by whether there is any better alternative. Those of you who are familiar with the well-known book, "Getting to Yes," by Roger Fisher and William Ury may recall those authors suggest that this question reveals the true source of all negotiating power. What your alternative is -- the degree of ease with which you can walk away from a negotiation and do better in another forum or do equally as well at any given point in time -- that, more than anything else, determines what your power is in the negotiation. Because, presumably, if the other side is there and wants an agreement, and you can walk away from it more easily than they can, they are going to need to try to find some way to keep you there. So they emphasize that understanding what your alternatives to negotiation are, as well as theirs, that's the most important calculation to make in deciding whether to negotiate or not. The authors suggest, quite wisely, that the most useful technique is to make your alternatives to negotiation "operational" and to avoid fantasizing about them. Rather than musing on how nice it might be to take a case to court, or to find another job, we can most help ourselves if we truly investigate those options, find out what kind of resources would be required, who would need to be involved and whether we could actually implement that alternative. This is the kind of analysis we so often fail to do either before or during a negotiation. Yet, making my alternatives clear is going to be the thing which best indicates in any given instance whether I should proceed with negotiation and if, at any point in time, the offers and ideas that I am getting are really ones I should accept.

There are a number of elements that people have suggested are critical to making a negotiation successful. Here I want to draw on my own experience. The first element is what is sometimes called the dependence of parties on one another. In labor relations, union and management really cannot make a living without coming to some accord with each other. That tends to have an enormous impact on the negotiations that they carry out. There is such a fundamental dependence on each other that those parties know that it is very likely they will eventually reach an agreement. The dependency is so great that they can tolerate a process of staking out very extreme positions and then progressing through the agonizing process of marching down the spectrum toward the middle. It is a costly, tiresome, and stressful process, but it illustrates the heavy dependency they have on one another.

As you well know, this is not the sort of thing that is present in energy and environmental conflicts. There, the relationship between the parties is extremely tenuous. In fact, in many instances, they have never negotiated with each other before. They fully expect they will never negotiate with each other again. In fact, they see many reasons to avoid negotiating with each other here and now. The lack of interdependence among the parties tends to make any negotiated process among them very, very fragile -- that is, difficult to initiate, delicate to maintain and difficult to conclude.

Where there might be negotiations on an energy or land use conflict the question to ask is: "Are these parties really dependent on one another; must they somehow reconcile their differences with each other?" One common way that dependency is created is through some form of administrative or legal proceeding in which they are caught and cannot extricate themselves for political, legal or other reasons. There are other ways in which parties may become dependent on each other, but it's very important to look at how likely they are to remain there.

Secondly, there needs to be a certain urgency about the conflict. I have had occasion to serve as a mediator and found that the parties had a problem that they wanted to discuss but there was no urgency to arrive at a solution. In this case parties may mistakenly and prematurally engage in negotiations. That can lead to a very unfortunate set of misunderstandings about what was agreed to and not agreed to and about how to modify agreements as circumstances change. Urgency concentrates energy and attention and gets people to put their resources to work to dispose of the problem. It causes them to make the kind of effort to understand each other that is so difficult and isn't something that people are readily prone to do.

Let me turn from negotiation to mediation. What mediators do is help parties negotiate with each other. It is possible to have negotiations without a mediator, but it is impossible to have mediation without negotiators. A mediator is available to assist parties in their negotiations but does not have authority to make decisions or bind them in any way. An arbitrator has that kind of power, but not a mediator. He is really there to help the parties do a better job at their negotiating.

What does a mediator do? One of the important things a mediator does is to help people understand that the other party's problem is their own. It's very easy to assume that their problem is something they have to solve; that they ought to come to the table with a solution to "their problem" while it is "my problem" that is the real issue. A mediator will suggest that devoting time and energy to solving "their" problem is the way you're going to be really successful in negotiation.

Mediators help parties decide on the kind of offers and proposals they will make. One of the most difficult things in negotiation is to know whether you are being firm enough or clear enough or concrete enough in any given offer, and at the same time, not to be so firm or so clear or so concrete that it causes the other side to walk away from the table and assume there is no alternative or compromise possible. A mediator can be a barometer in that situation. You can try out ideas, describe the sort of proposals that you might put forward and get signals on the extent to which they would be acceptable and useful to the other side, yet not overly generous.

You might think a mediator doesn't worry about parties being overly generous, but that is not true. A mediator really has an investment in seeing that any agreements reached work well over time. If people are overly generous, later on they are going to be resentful and will try to rewrite or undo the agreement they made. For this reason, a mediator wants the parties strike the right balance. This can be done by providing them with enough clues and signals about what is happening on the other side, so that the proposals they offer are right on target. Finally, a mediator can help parties decide to end negotiations -- whether what they're being asked to do is really worth their while -- whether at the eleventh hour, when the last best offer is on the table and they know that it has reached the point of take it or leave it, they can help a party think through what their alternatives really are. In a sense, a mediator can help parties avoid fantasizing either about the offer they've been given or about what their alternatives are.

The United States has actually seen a significant amount of experimentation and successful mediation of energy and environmental conflicts over the last ten years. I want to highlight just a few of them for you because they provide a certain concreteness to some of the things I've been saying. Also, each of them in its own way illustrates some of the problems and difficulties of doing this kind of thing. It is never a simple and easy thing to negotiate a settlement of these kinds of disputes and never easy to involve a mediator in them either.

First of all I'd like to just mention one dispute that has to do with the so-called Storm King Power Plant located on the Hudson River in New York. This was a situation in which for seventeen years environmental groups had battled with Consolidated Edison and other utilities over the question of the construction and operation of nuclear power plants along the Hudson River. A number of plants were in operation and many of the disputes at that time revolved around the extent to which cooling towers would have to be installed for these facilities. In addition, Consolidated Edison was watching their energy demands grow. Feeling a need to plan for the future to increase their capacity, they proposed to construct a pump-storage plant at Storm King Mountain. This would be an enormous facility costing hundreds of millions of dollars and the proceedings on the siting of that facility had dragged on interminably. Henry Luce, Chairman of the Board of Consolidated Edison, began to feel increasingly that there had to be some better way, one which would avoid increases in the cost of money and the cost of the project year in and year out. He wanted to talk with the opposition to see if they could find some way to accommodate each other.

He contacted Russ Train, then President of the World Wildlife Fund, former Administrator of the U.S. Environmental Protection Agency, and prior to that a Federal Judge in New York State and an eminently respected environmentalist. He called and said "Russ, can you give me any advice, any suggestions as to how I might be able to sit down and talk with these people?" Train offered a few comments and suggestions and Luce then got around to his real point which was, "Would you organize a meeting, would you chair a session, get us together with these environmental groups?" It was a formidable undertaking to bring these groups together. There were three different statewide environmental organizations, four other electric utility companies who had a stake in the power plants in question, four public agencies at the State and Federal level, all involved in the proceedings in one way or another. So, we are talking about organizing a meeting that would have involve sixteen or seventeen parties. In any case, Train did that and a series of negotiations was commenced.

The environmental groups were very wary and yet Train's credibility with those groups was such that when he suggested it might be in their interest to sit down and talk and that it would be a truly fair and open process, they knew they were not going to be caught off guard. They agreed to come to the table to begin discussions with Consolidated Edison. That led to a process in negotiation that went on for a couple of years, but ultimately encompassed a settlement of really extraordinary scope and depth in which the Storm King Power Plant was cancelled, the environmental organizations agreed to drop their opposition to the construction of cooling towers along the Hudson River, and Consolidated Edison and the other electric utility companies agreed to create a fund that would conduct research on the impact of cooling towers and other electric utility operations on the Hudson River fishery. The impact on the fishery resource in that river and many other detailed technical agreements about the way the cooling towers would be operated, the screens that would be used, the times of day that they would be operated and the volume of water that would be needed in the river before they could operate in order to protect the resource would also be studied.

It was a remarkable and an extremely successful settlement in the estimation of all of the participants in that process. It received nationwide publicity, though it wasn't the first time that environmental mediation had been used.

In 1973, in the State of Washington, then Governor Dan Evans had been frustrated by a longstanding battle between environmental organizations and electric utility companies over the proposed construction of a very large flood-control dam on the Snoqualmie River. Finally, in frustration, Evans called in two persons, Gerald Cormick and Jane McCarthy, and asked them if they would go on his behalf to each of the parties and suggest that they sit down and negotiate with one another. Environmental interests in that case actually had formed something of a coalition with the farmers in the valley below this proposed dam who felt very skeptical about its safety and their ability to withstand any potential break in the dam. Environmentalists were concerned about the enormous amount of acreage that would be flooded upstream by the dam.

After a long and very arduous process of negotiation, and with encouragement and continued pressure by the Governor, those parties were able to reach an agreement on the flood-control dam that allowed it to be constructed, that established a very elaborate early-warning system for unexpectedly high flows in the river that might put stress on the dam and other forms of protection for the farmers in the valley below. Inspired by this success, Cormick and McCarthy went on to mediate other cases in other states and Washington as well.

In 1976, I had the privilege of being involved as a mediator in a dispute over the proposed conversion of a very large electric generating station from oil to coal in Massachusetts. This facility, known as the Brayton Point Station, had been burning oil for about ten years. With the Arab oil embargo and the escalation in oil prices, the U.S. Department of Energy and the state's Office of Energy Resources were very anxious to see what they could do to cut dramatically the amount of oil consumed in New England. This thousand megawatt power plant had the potential to make a dramatic dent in the region's oil consumption. The issue was joined by the passage of the Energy Supply and Environmental Coordination Act by the U.S.

Congress in 1974, which gave the Department of Energy authority to order power plants to convert from oil to coal, but not without approval from the Environmental Protection Agency and the Governor of the State to provide assurance that environmental standards would be met.

When I first encountered it, the dispute was over whether or not the utility could be required to use a very expensive form of pollution control equipment known as scrubbers. These are elaborate systems used to remove sulfur from emissions. In this instance, it would have cost the utility something in the order of $180 million to build scrubbers for a power plant which, when it had been constructed, cost only $90 million. The company absolutely refused to pay twice the capital cost of the facility for a new and untested pollution control system. "No way on earth will we do that. We will spend as many years in court as we have to in order to avoid that outcome."

At the time, I was doing research in Boston on some of the problems faced by utilities trying to convert to coal and it occurred to me that this was a situation where the various parties might avoid being stuck in litigation for a long period of time by talking to one another. I invited them to come to our offices to meet and talk with one another. They shared a common agreement that reduction of oil consumption would be in all their interests and that, if there was any way it could be done without harming the environment, they would all like to see it happen. Together they found that a closer look at the research suggested that sulfur emissions, by themselves, were not necessarily the thing which ought to most concern environmental agencies. Rather, it was the fact that sulfur adheres to the particulate matter that drifts through the air and then is inhaled by people that was thought to be the most likely cause of emphysema and air-related health problems. This insight made it possible to consider a different pollution control strategy and to concentrate on a form of technology which was more familiar and much less costly, a system known as electrostatic precipitators. These are machines that give an electric charge to the particles as they come through the smoke stack; they adhere to a plate of the opposite charge; a hammer raps them and they fall down into a bucket. It's a very simple and very basic form of technology and was one which, upon closer look, seemed like it had a very real promise for this power plant.

It also became clear that the only way that the price of coal could be stablized was for the company to invest in a permanent coal supply from a particular mine and that, in turn, meant that the environmental standards to which they would have to conform couldn't be changed on an annual or even on a five-year basis. The company really needed some long-term commitment from the State that those standards wouldn't change. That ultimately led to an agreement to go the Legislature to seek a special waiver to allow the emission limits applied to this facility to remain unchanged for ten years. This provided the final breakthrough necessary for the parties to reach agreement in this case.

In 1978, they signed an agreement to allow for the conversion from oil to coal. The outcome was extremely satisfying. Savings of two hundred million barrels of oil a year, savings in energy costs to consumers, over time, of billions of dollars, and a reduction in air pollution from the facilities so that burning coal that was actually going to be cleaner than burning oil. This was the first case that I had ever worked on as a mediator and I learned a great deal about how complex and difficult a process it is.

I want to turn now to a case which may have some similarities to those you're familiar with here in Hawaii. It involves a very long standing dispute between fishing interests and oil companies over oil drilling activities off the coast of California. The dispute concerns the impact of the tailings from the oil drilling and the way in which they disperse or cause potential harm to the fishery resource. This situation had gotten to a point where fishing ships were attacking drilling rigs and seismic testing vessels because of the fishermen's fury over the incursion on their fishing grounds. It was leading to hostility and misunderstanding and paralysis to some degree in the activities of both.

With the involvement of a mediator, the fishing industry and the oil companies together with a number of companies that were involved in seismic research of various kinds, began to negotiate with each other on ways in which they might avoid conflicts. Over time, their negotiations allowed them to do a number of things, one of which was to set up a communications office on the mainland which monitored the movement of fishing vessels and oil company vessels to make sure that they never entered the same lanes or traffic patterns, keeping them from one another, getting involved in helping them to schedule in advance their trips in such ways that they wouldn't encounter each other. They could not always take the most convenient or quickest route, but they began to be able to develop their programs in conjunction with each other and in a sense avoid one another.

Also, they developed a scientific program of research on the impact of oil testing and oil drilling activities on the fishery resource in order to provide information to use in the future to manage these activities to sustain the resource. Those negotiations actually are continuing even now and are of such a magnitude that there isn't any single agreement which is going to bring to an end the need for discussion among those two groups. But I think it is again illustrative of the ways in which those interests which seem absolutely pitted against one another can, with energy and effort, sit down to talk with one another and find ways to work out their differences.

I would like now to take note of all that has been happening with environmental dispute resolution in the United States in the last ten years. There has been a great deal of activity. Recently Gail Bingham at the Conservation Foundation has collected information on this activity and has published a book on it. She notes that in 1977, there were nine major environmental conflicts settled through mediation; in 1979, there were eighteen; and in the years following that, more and more disputes have been mediated. By 1984, Ms. Bingham found that 160 disputes throughout the United States in various environmental areas had been mediated.

She points out that these occurred in a wide variety of areas with some involving more than one area. Among the 160, 86 were in the area of land use conflicts; 33 were in the area of natural resource protection, such as fisheries management, mining and timber production; 17 were in the area of water resources management, water quality and water supply protection; 14 were in the area of energy development and energy supply; 13 of them dealt with air quality impacts; 16 dealt with toxics. She also came up with some fairly interesting information about who was involved in these cases.

Only 33 percent of the cases involved environmental advocates as negotiators. Interestingly enough, business and industry groups were involved as negotiators in only 33 percent of the cases also. The occasions when both environmental groups and private industry negotiated with each other was only 18 percent of the total.

This undermines the stereotype that conflict and negotiation are almost always going to be between a private environmental group and a private developer. In fact, the truth seems to be that usually the group almost always at the table is government in some form or other. In fact, in about 85 percent of these cases, federal, state or local agencies were involved. So, frequently, there must have been negotiations between environmental groups and government on the one hand or industry groups and government on the other. Only rarely did you get the two private perspectives simultaneously at the table.

Ms. Bingham notes, with satisfaction, that of the cases where the parties wanted to reach agreement, 78 percent were successful while 22 percent were not. If better than three-quarters of the time these negotiations using mediators were successful, it is encouraging news. It also suggests that these were probably well-selected situations; that is, the mediation and the negotiation that went on were probably appropriate techniques for the particular disputes at hand.

What are the factors that are essential to agreement? Ms. Bingham suggests that there are three or four basic factors to keep in mind. First of all, as I was saying earlier, the parties have to have a real incentive to settle. They have to have no obviously better alternative to negotiation. Secondly, she observes that these negotiations were characterized by discussions of what the parties' real interests were, by attempts to help each other understand their mutual problems and points of view. She suggests this approach has a much greater likelihood of resulting in success than situations in which the negotiations are characterized by extreme and very rigid opening demands.

Another interesting point Ms. Bingham makes is that in instances where those at the negotiating table had the authority to implement the agreement, and to make it work, agreement was reached in 85 percent of the cases; not only was the likelihood of implementation increased, but the rate of success was increased as well. This suggests that perhaps there may be some difficulty in reaching agreement if the people at the table do not have the authority to make commitments that they themselves can deliver on.

Finally, she suggests that it seems like intervention by a mediator was avoided in negotations where it wasn't promising and increased the likelihood of negotiation in instances where it was. Ms. Bingham puts considerable emphasis on the fact that mediators discussed with both parties very early in the case whether negotiation would be in their interest. Mediators seem to affect the way parties come to the table and the way they frame their opening positions and how they deal with each other thereafter. That, I can assure you, was reassuring news for me!

Her findings are especially instructive about the role of government in these conflict resolution cases. It seems to me that when you're dealing with major conflicts over energy and land use, agencies are mandated to be involved in these cases to make sure that the decision-making that goes on will meet certain minimal standards established by legislatures at the national and state level. In the vast majority of cases, government is going to be a party to the dispute in some form or other.

At the Massachusetts Mediation Service, we have tried to respond to that by gearing our efforts primarily toward government agencies. We have tried to make ourselves available to them as a resource, to give them advice and ideas about how to manage conflict. We have said to them that in instances where mediators might be useful, we can provide a list of mediators. But there is a vast array of disputing going on and we recognize that only in a few very visible and very important instances is mediation going to be the right answer. So we have geared our attention and efforts very much toward public agencies, particularly at the state level, in order to do what we can to increase the frequency and improve the quality of their negotiations. Our hope is that they will be better negotiators, better strategic thinkers about the negotiations they are in, and better at deciding whether or not to negotiate. This we believe is going to have an impact in the long run on how well public disputes are resolved.

My last point concerns the kind of resources that you have at your disposal here in Hawaii. It seems to me, that with the Department of Planning and Economic Development co-sponsoring a conference such as this and beginning to think about the ways in which negotiation and dispute resolution may be useful, you are developing an awareness here that can be very valuable to you. Beyond that there are other programs including the program in the Judiciary that Peter Adler is involved with, and the Program on Conflict Resolution at the University. These people have a repertoire of skills, ideas, and strategies which may well reveal opportunities for you in some of the disputes that you're involved in that you hadn't realized were available to you. I suggest to you that right here in your own State, there are opportunities to take advantage of these resources and to have local expertise work with you in some of these cases to develop more effective, more skillful, even more enjoyable experiences in negotiation than perhaps you have had to date.

So often in negotiations, people worry about losing control; they worry about bringing in a mediator because they fear that the mediator is going to take charge. As you work with people here in Hawaii, I think you will find they are not interested in control, that the responsibility that you have and the opportunity for success you have, they want to leave in your hands. They are here to help you be better at what you are already doing and to achieve goals that you have in mind.

With that, I want to thank you very much for the opportunity to have been here and to say that I am very much looking forward to the remarks of those who will follow me this morning. I think it will provide more insight into the many opportunities here in Hawaii.

PATTERNS OF RESOURCE DISPUTES IN HAWAII

Tom Dinell, Director
Program on Conflict Resolution
University of Hawaii at Manoa

Disputes over the use of resources basically arise because what you are doing with the resource you own or control or what you propose to do impacts me or will impact me in a way that I believe is detrimental. The impact can be very direct. You propose to locate a residential care facility in the house next to me, and I believe that your doing so will provide me with undesirable neighbors and lower the value of my property. Or the impact can be somewhat more distant. You propose to locate H-Power, a garbage-to-energy facility, in my community, and I believe that the resulting stream of garbage trucks and the probable air pollution are going to make my community a less desirable place in which to live. Or the impact can be quite distant, at least geographically. You may be constructing a pipeline across Alaska, and I, even though a Hawaii resident, think it important that the reindeer can continue to make their winter migration.

Disputes over the use of resources may focus on the use of land, as in the examples above, or they may involve other resources such as geothermal energy or whales or the atmosphere or minerals in the ocean. Disputes over resources may be site specific, as in the examples I cited, or they may be about public policies governing the use of resources, such as environmental protection, or about administrative rules and regulations, such as the drawing of water from an acquifer or

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This paper is based in large part on the research conducted by students working under the supervision of the author in a Department of Urban and Regional Planning practicum in spring 1985. The research is reported on in: Dan Guerrero, Linda Kwitko, Pravit Leuchaikarm, Lelei Peau, Gazola Pirzada, Kristi Rowe, Falatehan Siregar and Audrey Yoshii with Tom Dinell, faculty participant, Land Use Dispute Resolution in Hawaii: Expanding the Options. Honolulu, Hawaii: Planning Practicum, Department of Urban and Regional Planning, University of Hawaii, July 1985, 142 pp. Page citations in this paper are to the above document. Some findings have been cited verbatim. Others have been paraphrased. The page citations in this paper are references to the basic document, Land Use Dispute Resolution in Hawaii: Expanding the Options.

stream. Today I am going to focus on resource disputes about the use of land which are site specific, that is, disputes concerning the use of specific parcels for particular purposes.

The practice of private ownership of land complicates but is not the source of land use disputes. Hunting and gathering tribes, which had no familiarity with the concept of private ownership, disputed over the use of lands. These disputes arise because land is limited, but the demand for it is not.

When disputes arise over the use of land, they may be settled in one of several arenas, depending on the nature of the dispute. "Legislative bodies establish general land use management policies including land use plans, mechanisms for resolving conflicts, assignment of responsibilities to specific agencies and general rules concerning property rights. They may enter into site specific land use disputes when the government is developer, an appropriation is required, public land is involved, or the zoning of a particular parcel is the matter at contention." (p. 9)

Administrative agencies are also involved in site specific land use disputes, sometimes in determining by rules and regulations how disputes shall be settled but also in applying rules and regulations and the underlying statutory policies on a case-by-case basis. (pp. 9-10) Administrative agencies also get involved in such disputes because they are the owners or managers or developers of land.

"Some site specific land use disputes end up in court, where there is a tendency to narrow the focus of the dispute to those issues which can be resolved based on written law and legal precedent." (p. 11) Occasionally a site specific land use dispute becomes the subject of an initiative or referendum as in the Nukoli'i case. (pp. 95-99) There are also traditional means for settling a dispute, such as ho'oponopono, but they are seldom employed today to resolve site specific land use disputes. (pp. 42-46 and 102)

Finally, in recent years, there has been an increasing emphasis on the potential usefulness of mediation and negotiation as ways of settling site specific land use disputes. (pp. 13-20) These newer approaches are not likely to replace the legislative, administrative and adjudicatory processes, but rather they expand the options.

There are also a large number of site specific land use disputes which never become formalized conflicts. They may simply simmer, such as an ongoing battle between neighbors. Some disputants may give up and either accept an existing situation or move to a new location or change their ways of living so that the offending use is not such a source of aggravation to them. Such disputes are not resolved; they simply are managed. And finally, some disputes, which are neither successfully resolved nor successfully managed, may break out in violence.

My concern today is with expanding the options for resolving site specific land use disputes. I believe there are some opportunities for doing so at this time. The climate is right. But at the same time, we need to know more about the nature of the site specific land disputes which confront us. Fortunately, a Department of Urban and Regional Planning student practicum undertook a study in the spring of 1985, designed in part to assess the characteristics of site specific land disputes and the potential for introducing new options for resolving such disputes. The client for the study was the Program on Alternative Dispute Resolution, established by the Hawaii State Judiciary "to explore, test and institutionalize the use of mediation and arbitration as methods of settling disputes outside the courts."

The study focused on site specific land use disputes in the judicial and administrative arenas. More specifically, administrative agencies included in the study were limited to the Department of Land and Natural Resources, the Department of Land Utilization, the Land Use Commission and the Department of Health. Only cases active during the period 1980 through 1984 were considered. Clearly, it would have been helpful to have included the legislative arena and informal channels and a longer period of time, but the limitation of resources precluded doing so. Of an initial sort of 120 cases, 91 cases were identified for analysis. About a third of these cases were still ongoing at the time the report was published in summer 1985. (pp. 22-29)

Trying to analyze 90 odd cases and identify similarities and differences was sometimes rather trying. Our cohort included disputes as to whether a pig could be a pet or not, on the one hand, and whether or not there would be a resort at Nukoli'i, on the other.

Let me report some of our more general findings first, and then talk about the patterns, or distinguishing characteristics, of specific disputes which we identified that made them more amenable or less amenable to resolution through relatively nonadversarial means.

Actually, very few site specific land use disputes go to court. "If the measure of effectiveness is cases which do not go to court, then administrative agencies are effective in dealing with land use disputes." (p. 101) Site specific land use disputes constitute only a very small portion of the total court calendar. While such cases take a long time to resolve, since they are not considered a priority class of cases by the court, they are not a source of overload for the judiciary.

When a site specific land dispute is heard in court, there is generally more emphasis on its procedural rather than substantive aspects. (p. 101)

Only one of the administrative agencies that we included in the study, namely the Department of Land Utilization, encourages mediation or direct negotiation among disputants, and this is done on a rather informal, ad hoc basis. (p. 101) Traditional dispute resolution practices, such as the Samoan "Fono" and Hawaiian "Ho'oponopono," play a very, very small role in the resolution of site specific land use disputes. (p. 102) There is a potential for utilizing aspects of ho'oponopono in settling such disputes, as evidenced by the King's Landing Case involving the Department of Hawaiian Home Lands. (pp. 93-95)

In some site specific land use disputes government plays a dual role. (See pp. 82-87.) It is both the developer and the decision-maker or adjudicator, though these roles may be played by different agencies or even levels of government. As developer, the government plans, constructs and finances these projects, securing any necessary permits along the way. As decision-maker, the government determines that a particular project is consistent with existing plans, is in the public interest and receives the necessary approvals and permits. Examples of site specific land use disputes in which the government has played the dual role of developer and decision-maker include H-3, Barbers Point Deep Draft Harbor, H-Power, Hale Nohalu, Makua Beach, Sand Island and Kawainui Marsh. In the Kawainui Marsh case, the government, even though the major owner, was not seeking to develop the land in conventional terms. Rather, it was a proponent for resource management and an adjudicator with respect to appropriate land uses. In this instance, unlike the other cases, the government used its primacy to bring the stakeholders together to engage in joint problem-solving and development of an agreed-to management plan.

Disputes that involve government as developer may occur frequently, as the cases cited illustrate. Government, that is, the legislative and executive branches, must make decisions about its own development interests and the public interest. These are not necessarily the same. Even when they are, other factors may intervene. These disputes can easily become clouded, continuing for many years. When government as developer engenders disputes which government as decision-maker cannot resolve, the disputes may end up in court, as has occurred with H-3.

It was our conclusion that disputes involving government as developer appear to be amenable to resolution through negotiation and/or mediation. All that is required is for government to commit itself to resolving such disputes using less adversarial approaches. "Government as decision-maker can decide that government as developer will work out potential conflicts with host neighborhoods or communities prior to the initiation of the project. Given the long legislative and judicial battles that occur when government is developer, there appear to be real incentives for government to enter into negotiation and/or mediation in an attempt to resolve such disputes early on." (p. 89)

We identified something we called the funnel pattern. (See pp. 65-69.) The further a dispute moves through the resolution process, the narrower the range of issues that are addressed. Substantive issues tend to be narrowed down to procedural questions. "In the Nukoli'i case, issues of crime, employment, racial tension, social justice, housing and the future of Kauai were discussed at various times." (p. 65) As the case moved into the courts, decisions focused on procedural matters, such as the moment in the permit approval process when rights become vested or the validity of the vote in the 1984 referendum. The West Beach controversy was taken to court on the basis that the Land Use Commission had illegally restricted Life of the Land from participating in the hearing process. The Queen's Beach case is being decided on the question of whether an area can legally be down-zoned, not whether resort development is desirable in that area. Similarly, fundamental issues concerning the desirability or undesirability of H-3 are not the basis for the decisions being enunciated in this case.

We uncovered another set of characteristics which we labeled the skip-over pattern. (See pp. 75-77.) In this pattern, complex issues involving social and psychological values are not addressed, leading to intense polarization and entrenchment of parties in their positions. These disputes often last many years. Even when a dispute is believed to have been resolved, if all the critical factors have not been considered, there is a tendency for a dispute to reappear in another guise. In the Sand Island and Makua Beach cases, the state acted to remove small settlements in order to create parks open to the general public. In doing so, the question of Hawaiian rights was skipped over. The immediate disputes were resolved, but the basic issues remained. They simply were not addressed. Some residents of the Waianae Coast have raised questions about the potential impact of the West Beach development on agricultural land, the shoreline, existing lifestyles, and the cost of housing in the Waianae area in presenting their case to the Land Use Commission. The extent to which the Commission can or will take such broader issues of development into consideration in making its decision is not clear. The tendency is to skip over value-laden and complex issues rather than address the underlying social and psychological factors. Consequently, these disputes may reappear in other arenas and are often prolonged for extended periods.

Our conclusion was that disputes which fall within the funnel and skip-over patterns might be resolved through negotiation and/or mediation if they were channeled into such a process during the early stages of the dispute. (p. 88) Both mediation and negotiation provide an opportunity to raise a variety of complex issues, discuss them, and perhaps deal with them. This may also occur in the legislative arena. Similarly, initiative and referendum permit such issues to be raised and discussed, as the Nukoli'i and Redevco Shopping Center in Hilo cases illustrate, though the nature of the voting process, namely, up or down, tends to polarize the parties and prevent joint problem-solving.

We also identified a pattern that we labeled the organized community pattern, which in one sense, is a truism; that is, the better organized or prepared a community is, the more capable it is of either fighting or negotiating. (See pp. 58-65.) Illustrations of the organized community pattern include Palolo Valley residents opposing the power line to be installed in their valley by Hawaiian Electric, the opposition of neighbors to the use of the Walker estate in Nuuanu for commercial activities and the resistence to removal of the Waikiki Natatorium. The well-organized community or interest group is clearly in a position to achieve its goals in either an adversarial or nonadversarial manner. In fact, the developer who desires to enter into negotiation or mediation with a community will find it easier to do so with a well-organized community or interest group that can deliver its constituency rather than with a poorly organized one that cannot. (p. 87)

We found that disputes which fall within the development-presumed pattern are amenable to resolution through negotiation and/or mediation if the agenda is limited to <u>how</u> the project is to be developed and not <u>if</u> the project is to be developed. (See pp. 77-80.) The developers of the Ronald McDonald House were willing to enter into mediation once they were assured that they had a right to develop the site they had chosen in Manoa. Mediation focused on the conditions to be placed on the permit, but not on alternative locations for the House. The Duplex Case, involving a community mental health facility in Pearl City, was similar. The Mental Health Association, sponsor of the Duplex, was willing to use mediation to gain some community acceptance, but was not willing to discuss alternative sites. The Halekulani Sea Wall case and the He'eia Kea Homes case, involving Hawaiian Electric, are similar. The Halekulani developer was willing to negotiate a settlement, assuming the pool and sea wall would remain. HECO was willing to negotiate with community groups and residents as long as the question was the nature of the development and not whether there would be a development. These cases illustrate how the presumption of development by the key stakeholders makes negotiation and/or mediation of a site specific land use dispute possible. Without such acceptance, resort to adversarial means is not only likely but necessary. If development is unacceptable under any conditions to those opposing a project, then there is no room for negotiation, though, it should be noted, people can change their minds over time about what is or is not acceptable.

Similarly, in disputes falling within the after-the-fact pattern, all that is likely to be subject to negotiation or mediation is how to mitigate the consequences or compensate for what has occurred. (See pp. 72-74.) The after-the-fact pattern is characterized by public opposition to a land use decision only after it has been implemented. "The public may become aware of a project or a violation of the law only after it has been in existence for a period of time. For example, a variance may have been issued, a building erected or a mural painted on a wall." (p. 72)

Residents were not able to close down Hawaii's first geothermal power plant, located near Pahoa, once it was in operation. Attempts to mediate the dispute were only partially successful. When the case went to court, the judge ruled that the emissions from the well did not pose a hazard to health. The outcome might have been somewhat different if concerns had surfaced before the project was constructed. Manoa Finance Company built some units that encroached onto the conservation district. After-the-fact, a petition for reclassification was approved and the developer fined. A community association took Manoa Finance and the Land Use Commission to court. The appeal, however, was dismissed, legitimizing the development that had already taken place. In these and other similar cases, ". . . the facility, improvement or project was already built, so the issue became one of how to legitimize what had occurred or to mitigate the impacts of the project. Courts in these instances usually do not order a structure to be torn down. . . Had the disputants been aware of the effects of the project before its completion, questions could have been raised and perhaps settled before the facility or project was built." (p. 74) Negotiation and/or mediation may be more suitable than the administrative or judicial processes for resolving disputes about mitigation or compensation, once it is accepted by the disputants that the improvements are to remain. (p. 88)

Disputes that require authoritative and binding definitions are not amenable to resolution through negotiation or mediation. We called this the definitional pattern. (See pp. 69-71.) The Bishop Estate leasehold land case, Midkiff versus Tom, raised the question of whether private property was being taken for a public purpose or not. Such a question is more amenable to settlement by an authoritative decision-maker, namely the courts, than by other means. It is simply not the kind of question that could be settled by negotiation. The Wave and the Whaling Wall in Waikiki raise similar questions. Are they art or billboards? What constitutes a dog kennel? "The Cronin and the Dog Kennel dispute went from the administrative level to the State Supreme Court, back to the administrative agency and again to the court. The dispute centered on conflicting definitions of dog kennels as an accessory use in a residential zone." (p. 70) "Connie Chun's pet pig is a similar case. The dispute, which also went all the way to the Supreme Court, centered around whether or not a pig could be a pet."

(p. 71) Disputes such as these, which require legally binding definitions, are not easily amenable to nonjudicial resolution processes. Such cases require an authoritative decision-maker to define the meaning of terms, apply specific laws, interpret constitutional provisions and/or set precedents.

The study on which I have reported today leads me to several important though tentative conclusions. First of all, each of the existing means for settling site specific land use disputes has its limitations. None is well suited for the settlement of all types of site specific land use disputes. The adjudicatory process may be the best way when the issue is what constitutes a dog kennel or whether or not a taking of property for a particular purpose is constitutional. But the adjudicatory process is not well-suited for dealing with fundamental development issues such as the desirability of resort development at Nukoli'i or West Beach or of an H-3 freeway across the Koolau mountains.

Secondly, the research to date suggests that there is a need to anticipate and analyze incipient disputes. How to go about resolving a dispute, or even avoiding having a dispute become full-blown, depends to a good degree on the characteristics of the dispute and the disposition of the participants or stakeholders. If a developer is only willing to discuss how a project should proceed, and its opponents are only willing to discuss why the project should never be undertaken, there is little room for the dialogue that is fundamental to negotiation and mediation. Whether to proceed with constructing a nuclear power plant at San Luis Obispo cannot be resolved through negotiation among the stakeholders. If the question, however, is what should be the nature of a particular development, then there is room for discussion and dialogue.

Thirdly, there is a need for much more information concerning the likely impacts of particular proposed developments. This information needs to be developed in such a way that both proponents and opponents of a project can accept the data as trustworthy and believe that the right questions have been raised and responded to. There is much to be said for joint data development or fact-finding, even recognizing that the disputants will interpret these data and weigh various aspects quite differently. Perhaps if the disputants in the Kahaualea Geothermal dispute or in H-Power had shared in the process of data gathering and data evaluation, the disputes would not have become as polarized and drawn out as they have. What becomes important is the availability of information on impacts and trust in how that information has been developed.

Fourthly, there is a need to establish procedures which facilitate people coming together to settle or resolve disputes which are likely to lend themselves to relatively nonadversarial dispute resolution processes. We may want to employ a process in site specific land use disputes akin to the newly-instituted court-annexed arbitration. We may want to provide a structured opportunity for mediation or negotiation prior to the hearing of a dispute by an administrative or quasi-judicial board. If we do so, we will want to provide some incentives to assure that such mediation or negotiation is undertaken with the serious purpose of dispute resolution and not simply in order to comply with some new procedural steps. Such procedures, however, should probably be set up in a way that assures the right of subsequent appeal as in court-annexed arbitration.

Fifthly, there is need for new and vibrant leadership in approaching the settlement of site specific land use disputes. We need to have developers, such as HECO, and community participants, such as the Kahaluu Neighborhood Board and Hui Malama, who are willing to sit down together and seek to reconcile their differences. They may not succeed in reaching agreement, but they are likely to narrow the areas of dispute and to vastly increase their understanding of what is important to others who have differing interests. The major candidate for this leadership role is government itself. If government as developer would look at the record -- H-3, the General Aviation Airport, H-Power, Barbers Point Deep Draft Harbor, Hale Mohalu, Makua Beach and Sand Island, on the one hand, and Kawainui Marsh, on the other -- then perhaps government as decision-maker would recognize that it has a major stake in seeking to work out such developments in a less adversarial manner. Government, in particular, has the resources to enlarge the development package so as to provide compensating benefits to those who are being adversely impacted by a public development. But most of all, government as decision-maker is in a position to change the manner in which government as developer approaches site specific land use disputes.

The task of resolving conflicts has been with us for a long, long time; it is a task central to the human condition. What is happening today, given the nature of political, social and economic changes, is that the old ways of resolving disputes are not working as well as they once did. In Hawaii, the oligarchy, for decades the primary societal decision-maker and thus the primary adjudicator of disputes, is long gone. Its successor, sometimes termed "government by consensus," is passing from the scene. The future could well be marked by major political and economic battles over the use of resources which lead to increasing polarization and further marginalization of groups in our society.

The alternative is the emergence of a new set of attitudes about the nature and function of disputes and the ways in which they can be managed, transformed and resolved. We may begin to conceive of disputes as providing opportunities for people to come together and increase their understanding of one another's interests. We may begin to perceive of disputes as providing opportunities for creating new solutions to old problems. We may begin to approach disputes as a means of providing opportunities to establish new relationships among disputants that will lead to a better future.

The research which I have reported on today does not imply that utopia is just around the corner. What it does suggest, however, is that by understanding the characteristics of disputes and the processes that are employed in resolving them, we can begin not only to expand the options for settling disputes, but also do a much better job than at present of matching particular approaches to dispute resolution to resolving specific types of disputes.

There is much to be learned about disputing and conflict resolution. The report on Land Use Dispute Resolution in Hawaii: Expanding the Options only scratches the surface. We need to know much more about the characteristics of specific disputes, about the impact of particular resolution processes on the attitudes and behavior of disputants, about who benefits from less adversarial approaches to dispute resolution and who benefits from the more adversarial approaches, and about institutionalizing new options for settling disputes. These questions, among others, are central concerns of the new Hewlett Foundation-funded Program on Conflict Resolution at the University of Hawaii. One of the projects of that Program, jointly sponsored by the Hawaii Natural Energy Institute and the Department of Planning and Economic Development, is specifically addressing disputes as they relate to the development of alternative energy.

But the learning endeavor is in no way the sole possession of a research program at the University. Rather, it is one which involves all of us. First of all, we can begin to analyze dispute characteristics and resolution processes so as to do a better job of matching disputes and the processes by which they are resolved. Secondly, we can expand the opportunities for resolving disputes in a less adversarial manner than at present. Thirdly, we can broaden the basis for participation in resolving disputes over resources and simultaneously change the nature of that participation. There will continue to be disputes over the use of Hawaii's limited resources. This is inevitable, given the different values we hold. What we can do, however, is to create a new and affirming climate in Hawaii for resolving resource disputes.

RESPONSE PANEL

Moderator, Peter Adler, Director
Program on Alternative Dispute Resolution
State Judiciary

INTRODUCTION by Dr. Peter Adler

As you already learned this morning, mediators don't impose decisions when they go around doing their work. Instead what they do is try to help people communicate and negotiate. And I think that's given rise to what I believe is the first real mediator joke that I've every heard. It goes like this. It seems that there was a mathematician, a statistician and a mediator and they were all standing around and talking about how much is two plus two. And the mathematician said that he'd been studying the matter and that he believed the answer could not precisely be determined with the best available mathematical theories and knowledge. The statistician said that he'd been studying this also and that he thought there was a 95 percent probability that the answer lay some place between three and five. The two of them turned to the mediator and the mediator took them off into separate rooms and said, "Well now, tell me, how much would you like it to be?"

It is my pleasure to introduce a panel to you that consists of Mrs. JoAnn Yukimura, Mr. Kenneth Kupchak, Mr. Hideto Kono, Mr. John Whalen, Mr. Arden Henderson, Mr. George St. John, Mr. David Matteson, and Dr. John Knox.

Mrs. JoAnn Yukimura is an elected member of the Kauai County Council. She is a trained attorney and holds degrees in psychology and law from Stanford and the University of Washington. She has been extraordinarily active in community and environmental affairs. In addition to being a mayoral candidate twice, she has helped launch a number of citizen organizations including the Niu Malu Nawiliwili Tenants Association, Save Nukoli'i Committee and the organization called Stop Hi-Rises on Kauai.

Mr. Kenneth Kupchak is a Director and Officer in the law firm of Damon, Key, Char & Bocken; he has also been extremely active in environmental and land use affairs and is a member of the Hawaii Coastal Zone Management Statewide Advisory Committee and the Kawainui Technical and Policy Advisory Committee. In addition to being a well respected attorney in Honolulu, he is also a trained scientist with a degree in meteorology.

Mr. Hideto Kono is a Commissioner on the State of Hawaii Public Utilities Commission and in January of this year was appointed PUC Chairman. Mr. Kono has a long and distinguished career in public service. He has been Director of the State Department of Planning and Economic Development, Director of the Hawaii Visitors Bureau, Chairman of the State Tax Review Commission and President/Director of Castle and Cooke East-Asia Limited. Mr. Kono also played key roles in the Territorial and State Civil Service Commission and in the formation of the East-West Center.

Mr. John Whalen is Director of Land Utilization for the City and County of Honolulu. He has worked as an Urban Planner in Latin America, on the Mainland and in Hawaii. He was a senior associate with the landscape architecture and planning firm of E.D.A.W. He has graduate degrees in Urban Planning and Public Law and Government.

Mr. Arden Henderson has agreed to substitute for Mr. Rod Moss this morning. He is President and Director of the Maui Electric Company, Ltd. He holds degrees in Engineering, and Business and Management from the Universities of Oaklahoma and Hawaii and has held a number of professional appointments with the Bonneville Power Administration and the Aluminum Can Company of America. He is active in civic and community affairs on Maui and is incoming President of the Maui United Way Board of Directors.

Mr. George St. John is President of Amfac Energy, Incorporated, the energy arm of Amfac. He is the Principal of the Puna Geothermal Venture on the Island of Hawaii and the City and County of Honolulu's H-Power project which was awarded to Amfac in July 1985. Mr. St. John is an electrical engineer by training.

Mr. David Matteson is Public Issue Specialist and Account Executive with Communications Pacific, the State's largest public relations firm. He is a trained mediator and facilitator and was formerly Director of the Neighborhood Justice Center's Conflict Management program which specializes in resolving development disputes. Mr. Matteson holds graduate degrees in Urban Planning, Public Health and Secondary Education and has mediated disputes over the Hanalei Bridge, the Ronald McDonald House, and the Duplex facility in Pearl City.

Finally, Dr. John Knox is President of Community Resources Incorporated, a private consulting firm specializing in social impact assessment, public opinion research and social program design. He holds a Ph.D. in Psychology from the University of Hawaii and has been both a newspaper and radio journalist. Dr. Knox has been involved in a number of development projects including the Village Park Expansion Program in Waipahu, the Kahe Point OTEC project and the Kuilima Community Interaction Process.

On behalf of the DPED, the Judiciary and the University, I want to thank all of our panelists for being with us today.

My job here is to try and pose a few questions to the panel to stimulate some discussion and some responses to the talks by Mr. O'Connor and by Dr. Dinell. In a little while, after we've gone through a bit of questioning, I'm going to ask David O'Connor and Tom Dinell to join us and open the panel to some questions, answers and comments by all of you.

Let me begin at the beginning. We have a tremendous list of who's who in land use and energy disputes and you've heard about some of them this morning. You've heard mention of Nukoli'i, Barbers Point, West Beach Development, the proposed Queen's Beach projects, H-Power and so on. Let me ask Mrs. Yukimura and Mr. Kupchak: You are both veterans of some very tough and complicated public controversies. Where do these kinds of problems come from and is there something inherent in Hawaii's political and social setting that requires us to have these long disputes?

Mrs. JoAnn Yukimura: Speaking from my experience with Nukoli'i and with the Tenants Association of the Kilauea Farmers and the Ohana of O'Mahalopu. I've been in government for a while, so I should say that I may not be the best citizen representative because I have one foot in government.

But as I recall my earlier days, the problem and in fact the reason why I finally decided to run for office, was that citizens were cut out of the decision-making process. They could go to public hearings and speak their positions and even offer all sorts of data and documentation but that seemed to be form only and something that did not seem to have any impact on the decision-making process itself. And so I feel that that's where the citizen uproar and anger comes from.

Mr. Kenneth Kupchak: That's a tough question. When I first came out here, one of the things that struck me as different from what I was used to, was the fact that we had only a two-tier system of government. With the second tier being the County level, people in many areas around the counties feel somewhat unrepresented; government as a whole seems too big. They drop out of the process or the process does not absorb them in such a meaningful way that they feel that they have an impact on the system. Oahu, some years ago, went to the Neighborhood Board System in an effort to overcome some of the alienation that some of the people in the community felt. I think it is necessary to make every member of the community feel that he or she has an active part in the government. They don't trust some of the systems unless they are. Therefore, they come up with their own groups; they have to advocate through the media and the courts to get the attention of the decision makers. It's like getting the 2x4 to hit the jackass on the head to get his attention, to get moving, if you remember the old joke about the donkey. I think the primary reason is that you want to be listened to. The mediation process we have been talking about today may provide the alternative to that.

Dr. Peter Adler: Let me shift. Mr. St. John and Mr. Henderson, you both in a sense are here representing elements of private industry today. Do you view these conflicts as inevitable and could you tell us a little bit about what you do to prepare at the front end of a development project and how successful are those efforts?

Mr. Arden Henderson: The area that I deal with as a utility representative is a little off of what Rod Moss would have spoken of but I think it applies along the same line. The conflicts that we see, particularly on Maui, really do concern us and address the question that you directed to me. Because we are a growing island, we have an airport that is overcrowded and for lack of resolution of what the safety, health, and crowding aspects would be some years ago, we were forced into a situation where the airport is expanding. It had no choice. But it is expanding in a way that I think all the people involved in the conflict situation would not best be satisfied. The problem has to be solved. And I think that's what we're facing all too often and I think this is a result of a lot of the kind of delays addressed by Kent Keith and by Governor Ariyoshi. I think we really need to look at what was being said this morning in David O'Connor's remarks. The conflict resolution is at the wrong end. By the time it got to solving the problem of the Hudson River project, by the time it got to the point in solving the problem of coal conversion, the money had already been spent. It was too late. And in the case of many of our projects on Maui having to do with wind-generation siting, geothermal exploration, the airport, landfill sites, the water quality situation, these need to be solved at the front end. What I would like to see consideration given to, and I think Tom Dinell did address this for Hawaii, is that it needs to be at the front end. We need to address what the problems are, try to get people together in agreements to form some consensus so that we agree how a project should be done, not if it should be done. This should be done at the front end.

Mr. George St. John: I am trying to respond, I think, to two questions. One is what do we do to prepare for conflicts and the other is are the conflicts inevitable? I don't think the conflicts are inevitable, but I think disagreements are inevitable. The projects that I've been most closely associated with have for the most part been very large and they've been designed to serve a large portion of the community. But, as it was pointed out this morning, they have to go in a very specific place. Any individual is apprehensive about having a major facility located in his neighborhood. That's only natural and only to be expected. What we do to prepare, what we do now versus what we might have done in the past, hopefully are different. I'm certainly not prepared to say we have answers. I've certainly learned in the projects I worked on.

The individuals that are concerned are genuinely concerned. Many times they are genuinely frightened. Sometimes people do have other agendas. But the fellow who has a home, who has a family he's worried about, can become truly alarmed about the project's having some rather dramatic and negative impact. And it's difficult sometimes for him to obtain information. I think that's where the advocates of the project have a very large responsibility to do a good job of communicating. That point was made this morning and what we are trying to do now is to disseminate information. It's sometimes difficult to have people believe you if you are a developer. It's a natural thing for the person who is suspicious or skeptical to believe that you are selling only one side of the story. We always try to be as factual as we can, but the person doesn't necessarily know that. So you need a way to communicate to them what the real impacts are so that they can understand. For instance in Waipahu, when we were talking about locating H-Power there, there was a concern about the traffic. It was somewhat overlooked that there is already an incinerator in Waipahu and a fair amount of traffic went to that incinerator and still does to this day and will continue even with H-Power. If H-Power had been located in the community as originally planned, the traffic to the incinerator would have decreased over the streets that were of concern. It's a detail but a very important detail to those people who live there. So what would we do differently? I think we would try as much as we possibly can to get the information directly to the people who are concerned.

Are conflicts inevitable? There's going to be a difference in opinion because we are trying to serve a large segment of the community. For an airport, a power plant, a resource recovery facility, most of us don't want those kinds of facilities near our homes. So our own personal interest is not the same as the overall community's interest. We all recognize, speaking from a community perspective, that most of these facilities are needed. But from our own personal perspective, we all recognize that we'd much rather have our own large backyard. So I think that there will be a difference in opinion on whether or not we can avoid the conflicts. I certainly hope so because I can tell you they're extremely expensive. Whether they are inevitable or not, I just don't know.

Dr. Peter Adler: Thank you. Mr. Whalen and Mr. Kono, you both represent important government agencies that administer or regulate various kind of matters. Certainly one of the roles of government in the generic sense is to help resolve disputes. As you survey the present landscape of the kinds of issues we've been talking about here today, what kinds of disputes or conflicts or issues seem to be getting handled effectively and which ones don't?

Mr. Hideto Kono: You notice Peter Adler put the government types between the environmentalists and the developers. And you also notice where the mediators are; they're in the left field! They have been that way. Hopefully, they will get more into the center and help us resolve some of the problems. I'm sure that it's presumptuous on the part of Mr. Whalen and me to represent government perspective because as you know we have at least three levels of government and three branches of government in Hawaii. But, we are faced with making decisions. That's the nature of government. Whenever the environmentalist and the developer get together there are going to be multiple issues and we have to make those decisions. As others have pointed out earlier, when the issues are abstract, generally we can resolve those problems. But if they are site-specific issues that involve one person's backyard, or those that involve a lot of money, we have a hard time making decisions because if we make those decisions without following the legislative procedures, or what the court believes are steps that have to be taken, pretty soon in the litigious society that we have, individuals will bring us to court and delay the process. Certainly it's desirable that we help find a position that is acceptable to the bodies involved but that's not very practical or realistic. Hopefully, we as members of society realize that we're all in the same canoe. Therefore, we compromise and allow certain things to occur even though we don't particularly like them, so that the entire society is benefited and by that way, with that strong motivation, we are able find some sort of a solution.

Mr. John Whalen: The Department of Land Utilization is often an arena for some very heated disputes, often affecting people very directly. Proposals for uses in residential neighborhoods, for example, often become very controversial because they affect people so directly and at close range. I'd say that some of the more difficult cases or the ones where the debate gets more acrimonious and people get very emotional, are cases of projects where people suddenly become aware the proposal exists. It seems to have come out of nowhere. Often that's not the case but suddenly people become aware of it, usually through a public hearing notice. The lack of information or the lack of awareness of the project itself becomes a point of contention and people feel that they hadn't been properly informed. I think some of the opposition might actually be assuaged if people had felt that they were a part of or at least had information about meetings early on. In other cases, a project proposal may have been around for quite sometime but had gone through other arenas or other types of procedures. Maybe it was more abstract at an earlier stage and people seemed not to have been following the proposal as it developed.

I'm not sure what the solution to that is. However, it seems that one of the inherent problems that we face now that seems to lead more to litigation these days is our multiple permit system which has been an increasing trend over the last decade or so. This tends to compartmentalize issues and the parties involved in disputes or potential disputes. It also diffuses those issues. As a result, with all the multiple permit processes there seem to be, that by the time dispute goes to litigation the arguments center around procedural questions and definitions. I wouldn't say the substantive issues are lost completely, often they are subrosa, but they're not right there being discussed in court. This focus on procedural issues tends to lengthen the permit or the approval process even further because the court's decisions require greater notification. So it becomes a vicious cycle. Often we find also when there's a protracted decision process with one sequential process after another, positions often get hardened over time between the various parties involved; the range of feasible alternatives for the developer become narrowed as time goes on. Often there's more flexibility at the beginning but later the options narrow because of economics.

Dr. Peter Adler: Let's jump now to the practitioners. Mr. Matteson, Dr. Knox. From your point of view, why aren't more people availing themselves of mediation. If this process is so good, why aren't more people using it?

Mr. David Matteson: I think there are a number of reasons. First, it appears to be a novel approach for many people. It's unfamiliar to them; they have a lot of investment in doing things in tried and true ways. But I might interject here the concept that a lot of people have a tool bag that they carry around with them and the only tool that they have in that tool box is a hammer. In that case, it makes everything in the world look like a nail. This is sort of standard human nature; we believe that a certain approach should work and continue to pound away at that approach in spite of apparent unsuccessful attempts. Perhaps it worked once and there's that sort of intermittent reinforcement approach. I think people don't avail themselves of mediation yet because they don't know what it's all about and they are clinging to old habits in some ways. I also think that presently in Hawaii, at least, there is not a lot of visibility for the work that has been done.

The conflict management program with the Neighborhood Justice Center started almost five years ago. It mediated over 60 cases, eight or nine of those rather major cases, with a fair amount of success and yet there has not been a lot of visibility about the achievements that have been made in that area. There have been a number of events that have taken place, particularly those sponsored by DPED, where an agency has brought in neutral and impartial facilitators to run meetings. Not the least of these was a recent one that Kent Keith brought about several weeks ago based on the question of siting the convention center. DPED took a very active leadership role to try and apply a new way of doing business to an issue that is very early in its evolution.

I think another reason that people don't avail themselves more often of mediation or negotiation is because they are confused. There is not a lot of basic theory that we can draw on; there are not a lot of case studies that you can look at and get anecdotal insights. I think negotiation, as was pointed out earlier, is not universally applicable. There are certain conditions under which negotiation is appropriate; there are a certain conditions under which mediation is appropriate; there are certain conditions under which the court process is appropriate. Although I think we are beginning to have some pretty good insights into situations where various techniques or strategies are best applied, we still don't have any hard and fast rules. The landscape shifts constantly and particularly in public policy disputes. There is, I think, a natural history to these that is rather predictable. We don't have a lot of good data to rely on, to draw a model of what a public issue looks like over time, but we do know that interests change over time, the parties change, and positions change as new information becomes available. At various points along the way, you may want to be applying different techniques, and how do you know who you're playing with if parties keep changing, and how do you know what the right technique is if the landscape keeps shifting? So there's a certain sense of, "I don't want to get involved in that because it's just too unpredictable." But I think that the advantage in continually looking to apply some of these ideas is that you are then trying to continually maximize your opportunities at any given moment. There is a tendency to try and reduce a complex situation to familiar patterns and there is a real danger in reducing a complex situation to a pattern too early. People will then take a position; they'll decide this is the strategy we need to play with and they'll hold on to that for dear life because that's the only thing that's predictable, because they said, "We made this decision and we're going to stick to it." That's when you begin to see people get highly positional.

Dr. John Knox: The City Council commissioned the study on the social impact management system which, as originally conceived, was to provide incentives for both communities and developers to get together early in the process to head off conflicts. For whatever reasons, it was not ultimately implemented. I think another reason that negotiation or mediation has not been often tried in Hawaii is the question of incentive. I notice that especially the citizen groups and developers who are getting more and more interested in negotiation are people who have had experience in conflicts, who have had their heads bloodied. In Tom Dinell's practicum report there was an interesting sentence, "Its unlikely that you're going to have people interested in getting into mediation or negotiation if they believe they are involved in an epic heroic struggle, a good versus evil." That sort of mentality I have encountered on both sides of the fence and it's usually early in the process, when people are having their first experience in getting in there. They don't know the other side. They are able to characterize the other side as irresponsible while they are on the side of the angels. The longer they are in, the more they realize that it's not that simple and they begin to look for another way. Possibly a third reason has to do, as John Whalen mentioned, with the many layers of permits and many layers of planning that exist. At the moment I think it would be very valuable if we began to give some thought on how to tie the type of negotiation and the objectives of negotiation to the level of planning that we're talking about. For example, when we're dealing with the General Plan change on Oahu and the Development Plan change, that's a general level of planning decision. One of the problems is that we get into a set of negotiations and we may end up trying to nail down every single detail. We've got to come up with tiered system, just as our permits are tiered. They began at a very general level and get down to a very specific level into zoning. We've got to come up with systems which match the level of decision-making.

Dr. Peter Adler: JoAnn, did you want to add something?

Mrs. JoAnn Yukimura: From a citizen's viewpoint, I think the reason why mediation isn't used very often in Hawaii is that citizens don't know it's available for one thing, and sometimes it isn't actually available. I'm thinking of the case of Nukoli'i. This has to do with government and its potential for promoting mediation and its use. One of the problems in Nukoli'i was that government was not viewed as an impartial decision-maker. It really looked to citizens as if there was collusion involved between government and the developer. Just look at the sequence of events. Citizens appeared in full force at the General Plan hearings and then at the zoning hearings. Before the zoning decision was made, there was a general election; it was a big campaign issue and four Council people were elected who stood for no development at Nukoli'i. And three months after the election, the zoning was passed with a majority of four out of seven Council members for a resort at Nukoli'i. Then the citizens challenged the Shoreline Management permit; went to court on it; and got the developers on their illegal sewage treatment plans. I mean, it's just a series of events that made citizens think that, "There's something going on here." Not to mention the building permit which was issued the day before the initiative and referendum. And so...it would have taken a lot for government to look like an impartial decision-maker or at least be willing to mediate and it didn't seem like it was in that case. I want to say that I&R (initiative and referendum) has been touted as one way decisions are made. It's a terrible way, in my opinion, to make a decision. But in the case of Nukoli'i, from the citizens' perspective, it was the only resort -- it was the last resort. We had nothing else. We had tried everything -- the democratic process of elections, all the public hearings and administrative reviews -- and nothing seemed to work. That's why citizens went to I&R. Of course as was demonstrated later, it's a double-edge sword when you have lots of money that can handle the publicity and so forth. But either citizens don't know mediation is available, or they don't know how to use it. It's a very unfamiliar tool and so people don't know what it actually involves and they don't know how they will benefit. I think there are a lot of misconceptions that it will involve a lot of compromise and sellout. I think there is a lot of room for education from the citizens' viewpoint on how it could really help on both sides.

Mr. Kenneth Kupchak: I want to reinforce a number of things that have been stated. The public interest groups and citizens' groups generally do not want to litigate. It's a last resort alternative. It's very costly. I spent three years on the Kawainui situation, I'm in my fourth year on geothermal and Boyce Brown has obviously made a lifetime out of H-3. We don't get paid for this...most of us would rather do other things like spending more time with our families. All of the people that usually support these activities are volunteers. Most often, the only thing that these people want is for the decision-maker to listen to them with undivided attention and to explain the results in a manner that's understandable especially if the results are contrary to what the citizens want. We want to know why the decision was made and why our positions were not acceptable. I assume in most cases there are reasons, but when the results are not explained or not listened to, we don't trust the process. We need to have the rules of the games spelled out in advance. I agree that I'd like to have front-end resolution on most of these items but this requires an effective advance notice system. With respect to Kawainui, under Mr. Kono's leadership, we put together a task force at the State level. We involved all of the parties and I think came out with a very good plan. We had people from the community, we had the environmental groups, we had industry and we had the Chamber of Commerce participating with the government agencies. We spent a year or two hammering out the results and I'd like very much to see that implemented, so that we'd have a concrete example that government can take the leadership to bring the parties together. With respect to geothermal, we've had a number of efforts to reach some sort of agreement between the developers and the community people. The process that's taking our time at the present is a result of some listening to views. We are considering land exchanges and I think that the issue is no longer whether the project should go forward, but as Tom and David indicated "how." We have, in fact, today the beginning of the next session on contested case hearings on geothermal and the first conflict I had to resolve was whether to be there or here. One other example I want to call to your attention has to do with the neighborhood boards and the general planning process. When I was head of the Kailua Neighborhood Board, the Department of General Planning and DLU would require most of the developers to come and talk to us before they made their applications. It was my opinion that that process alleviated many disputes. We had developed in Kailua, through a series of surveys, an idea of the kind of town we wanted and we talked with the developers on how to fit their proposals into that concept. We were sharing our mutual interest in trying to accommodate both and I think that process ought to be continued.

Dr. Peter Adler: David, did you want to add?

Mr. David Matteson: Yes, thank you, Peter. I want to go back to your first question which was "Is there anything unique about Hawaii?" because I think that's important. I think there are a couple of things that make Hawaii different from some of these cases that you see on the Mainland. Hawaii is a small community. We all know each other's business. Every land use or public policy debate impacts each of us fairly closely. It's not like we live in the mid-West where an alternative would be to move the factory or the proposed project out of the city. We are very, very sensitive to the question of regional benefits and local costs. And I think to answer your question, "Why aren't more people utilizing mediation?" I think it's partly because we have long memories in Hawaii. People carry around a fair amount of baggage from one dispute to another and so there is a tremendous amount of mistrust that needs to be overcome. Where does that mistrust come from? It comes from getting bad advice, I think. So I'm really delighted that there are so many people, not just saying negotiation or mediation is a panacea for you, but helping people. As Tom Dinell mentioned earlier, one of the needs is for people to understand better their own disputes or their own role in various issues so that they can make more intelligent decisions, so that the right information does get communicated. Because you could have the best information in the world and unless somebody is ready to hear it, you're never going to get through to them.

Dr. Peter Adler: Mr. Kono, did you want to add something?

Mr. Hideto Kono: Yes. Somebody said that you really don't have mediation without conflict. I think this panel is too mild. We ought to have a little bit of conflict. From the government perspective, you see the developers often are so used to making decisions from the top that it is difficult for them to consider all aspects of their development. Oftentimes, however, the environmentalists need some kind of education because the answers are somewhat confused. But often times I see that leaders of the environmentalists have some hidden agenda or they represent that they are heads of the group in showing the short term without really looking at the balance of what is in the general good. Often times, as you know, the leaders of the environmental group begin to build a constituency and pretty soon you see them all running for office. Often times, faced with this problem, and as you know the government fellows are short-time fellows or sometimes they have kids and have mortgages on their houses and so they are afraid to make decisions. It's very important that government administrators in the conflicts not delay these things but make a decision and face up to it. For this we need good administrators. We need to educate and train our bureaucrats to make decisions in a timely fashion. I hope this provokes some controversy.

Dr. Peter Adler: Let me ask a question to Mr. St. John and Mr. Henderson. Let's say that you were facing a situation on the siting of a facility and you were predicting there was going to be community opposition to it. What would you do; how would you go about finding a mediator; how would you begin to initiate that process? If you decided that you really did want some outside assistance with the negotiation process, how would you do it?

Mr. George St. John: I'm not always sure that we would want necessarily to start with mediation. In fact, with H-Power for instance, we did start with the neighborhood board and you may find this quite surprising. H-Power was endorsed by the Waipahu Community Association. That was rather shocking to many people, given the end results. That endorsement was subsequently withdrawn and the whole process was turned around. I appeared on several radio programs and met in more coffee meetings that I can possibly keep count of, but nevertheless, the result that came out was negative for the project at that site. So I think Mr. Kono has made a very valid point. Communication is not always the answer and mediation is not always possible. The situation exists, sometimes, where people just plain don't want a facility. Its merits are not the issue. The facility from their perspective will not be here and a clever person, an intelligent person can in our society stop a project. You need no greater proof. In our community, the moving of H-Power cost all of you who live here at least a hundred dollars each for it to be located in its new site. That's the capital cost. The operating cost is even higher. So the citizen does have tremendous power, tremendous capabilities.

We were supported by the City, we were supported by many of the leaders in our community who all felt that there was tremendous synergism by having the sugar mill and the project together. Yet a relatively small group of people, who for the most part I believe were very sincere in their beliefs, were frightened of this project and by combining their efforts, they were able to stop it. I don't know if mediation would have helped. It might have. I'm sure that better communication can always do a better job. But it wasn't due to lack of effort on the part on the City, on the part of private industry that was involved, or on the part of the community in trying to understand in this case what the project was. I think there was just a legitimate difference of opinion as to what was right and what was wrong, and the citizens of Waipahu in this case got what they wanted, they got the project moved.

Dr. Peter Adler: Thank you. Let me ask a very different kind of question to Ken and JoAnn. Both of you are lawyers. Do you have any sense that an attorney working on either side of land use and energy siting issues might be inherently distrustful of proposals to mediate or negotiate? That's the first question. And the second one is, do lawyers sometimes get in the way of negotiation and settlement discussions?

Mr. Kenneth Kupchak: I think it has more to do with personalities than the profession. I know I'm involved mostly, not because I'm a lawyer but because I have a chemistry degree, a meteorology degree. I was a practicing meteorologist for several years and I'm an amateur botanist and geologist and I have a lot of knowledge on Hawaiian history which interrelates with all of that. These issues come up in almost every case and that's why I've been involved them. With respect to whether the lawyers help or don't help; some do and some don't. I sensed in some of the proceedings I've been involved with, a hesitancy on the part of the opposition to deal with me on some cases and not on others. And the ones where I sensed the hesitancy, I felt that there was an attempt to gain an advantage over the client who was not as sophisticated in the matters that were before them. But in some of the other cases there were personalities involved and that would have occurred no matter whether I'd been a lawyer or not. There's a fear of a lawyer because he knows the system. Many times a volunteer from the community has no idea what's going on in the system and they need some assistance. If they are left to their own, they can be taken advantage of, in some cases. Over the years, we've developed a pretty sophisticated public interest group so they don't always need the lawyers any more.

Dr. Peter Adler: JoAnn, do you want to add anything?

Mrs. JoAnn Yukimura: Yes, I don't think lawyers as a group get in the way of...or, let me say, would be afraid of negotiations or mediation. It seems to me it's a normal part of their daily routine and that it would be something they would feel at home with. In terms of whether they interfere, I think it is more a personality issue in terms of resolving disputes.

Dr. Peter Adler: Any other thoughts? John?

Dr. John Knox: Let me go back a moment to the question why mediation is not turned to as much as it should. David pointed out that most of the successful documented mediation cases have involved government and quite often are, in fact, between various government agencies. Tom Dinell talked about the fact that a well-organized community is more easily dealt with than a loosely organized community. Many of our disputes in Hawaii have been between a private developer and community groups. And many of them have involved anxiety on the part of an entire community. I think the Waipahu situation was an excellent example of an initial group of people taking a position, but they couldn't speak for everybody in the community. And that is the nature of those types of disputes. It's very hard to get all the stake-holders at the table or some elected representative of all of them to be there. In those kinds of "not in my back yard" or similar concerns, we have to come up with some kind of validation procedure. We don't have it yet. We don't have a way of bringing the Waipahu Neighborhood Board together and working out an agreement with them, but then making sure of taking it to all of Waipahu and getting all of Waipahu to sign off on it. There are some possible avenues to explore, surveys, etc., but I think that's an avenue for research on the part of universities.

Dr. Peter Adler: At this point, I'd like to switch gears just a bit. I'd like to invite David O'Connor and Tom Dinell to come up and join us in the panel. And I want to throw the floor open for ideas that you'd like to express or questions either to individual people or to the panel as a whole. There's a microphone in the center there and feel free to step up or if you have a loud booming voice you can just stand up.

Mr. Hideto Kono: You mentioned lawyers and certainly that should not go by without comment. I like lawyers individually but we have too many of them. And the only way they can really survive is to increase their work load and that means they are going to have a lot of paperwork generated, a lot of controversy. The tendency and the training of lawyers is to take either the positive or negative. And when they take the negative, they push the negative to the hilt and the positive fellows, the complainers or the defendants and the plaintiffs, all take very extreme positions. And so they favor also a contested case, in which a lot of people are allowed to voice their opinion, but in a structured way. When you have a structured method, you have a pre-hearing conference, you have the interrogatories that pile up into tons and tons of paper. This is expensive for the citizens who are the taxpayers. But, you know, this is a system we live by. If we can avoid too much of that legalistic approach to the solution of our problems, I think we're that much ahead.

Dr. Peter Adler: I believe this gentleman has a question or a comment.

Comment: I'm from one of the neighborhood boards. I'm a planning chairman and in planning I read a lot of material that comes across my desk, but it's long and involved. Sometimes I think it should be written in a clear text, say for about a tenth-grade level, because we do have to go out in the community to explain it to the people and to get their interest. Because the worst thing is to have a board meeting and have nobody come. Then, you don't know peoples' concerns and have to run a survey which is expensive and time-consuming.

Dr. Peter Adler: So are you saying that many discussions are conducted in such abstract terms people don't understand what's going on?

Comment: I'd say a lot of what is written is written probably for someone with a graduate degree in law or for planners with masters degrees. If these plans could be written down to a level for the people that they are going to impact it would be better. Also planning seems to take a lot of money and it almost seems as if research firms make money from it. It seems to be a long and involved process which adds to the cost, in addition to delays with the environmental groups fighting and other community groups fighting specific areas.

Dr. Peter Adler: Does anyone want to respond to that...any additional thoughts?

Panel Member: He makes a very good point and I think this gets back to the question that was asked. How do you chose a mediator or do you really choose a mediator? One of the things that I've had brought up to me from some of the people that we have talked to, they are in a conflict situation in the first place because of mistrust. And if you get somebody in as a mediator, somebody who is part of the negotiation process that doesn't really have rapport with the people that you are trying to talk to, it's bad. The people I've talked to, by and large, I think they're sincere, they want to understand the situation. I think the worst thing that can happen is to have a situation come up so that out of that negotiation process, out of the process we go through to try to give information to the people who are truly expressing concerns, is to have this mistrust. A mediator needs first of all to be someone who is willing to really see what the local situation is, what the true concerns are, and then to respond to it in a way that that particular group or that particular neighborhood can understand. It should be put on the level that doesn't take a PhD to understand what's written or doesn't take a lawyer to interpret it. It needs to be put into that kind of framework and I think the selection of the person you're having to do this is extremely important.

Dr. Peter Adler: John Whalen, a comment?

Mr. John Whalen: I'd like to add something. I think one is that neighborhood boards and other community organizations are voluntary organizations and not only is it a matter of having the material in understandable form but there's so much material that goes to each of the neighborhood boards it is difficult even if you're able to understand it, to absorb it all. One of the things that I feel public notices help to do is to sort out at least what is percolating and maybe to identify the kinds of things you really want to know more about. I don't think that anything can really substitute for a meeting with people who are proposing projects in the area and having a question and answer period. We encourage all applicants where we think there may be some major issues to approach the community organization or neighborhood board and make a presentation and be available for questions and answers. I think that's a much more effective way than trying to read all the material that comes through.

Mr. Kenneth Kupchak: On the same point, I had written an article in the Hawaii Architect magazine a number of years ago on the "Role of Neighborhood Boards in the Planning Process," and I went through a lot of these steps which you may like to take a look at. In the Windward side we also had the benefit of having something called the Windward Regional Council, which is a non-profit corporation. It was set up and it hired a planner who was available to answer questions and educate the community leaders. When the neighborhood boards came on line, we closed down the Windward Regional Council in hopes that at some point the neighborhood boards would be given some sort of planning staff, not to make decisions for them but to educate them. That part of the process has never come on line to my satisfaction. I know during the Development Plan process the city put a lot of effort in educating the neighborhood boards but after those people left, the new group that was coming on didn't have the education. I think we need to have some sort of planner available to the community groups to educate them.

Mr. David Matteson: I appreciate your point about the neighborhood boards' position in trying to disseminate information and collect information. The neighborhood boards, at least on Oahu, have really become the interface between government and communities and in many cases between developers and communities. In the Development Plan process, in the amendment process, and even in the permitting process, there are numerous opportunities where there are requirements for an exchange of ideas or at least "public input." I want to stress, negotiation is not something you apply at all points along the development of an idea from the concept all the way to the final finished project. But there are facilitative behaviors, if you will, techniques that a mediator uses to facilitate improved communication that neighborhood boards could use. There are better ways to run meetings than the "you've got three minutes to say your piece" public hearing approach. There are better ways to make people feel that they've been heard. I think Ken raised that point earlier. Sometimes people get involved in a dispute simply because they didn't feel heard. So I think there are a number of things that we could do to improve the existing system, to allow the communications to be more effective as well as, perhaps, put in mediation in a place where the dispute is right. David, I know you've had some experience with sitting outside permitting offices in Massachusetts looking for work, but perhaps you could comment on this.

Mr. David O'Connor: One place that we could put a mediation clause would be between the issuance of a permit, perhaps between the issuance of the permit and the Zoning Board of Appeals or before the contested case hearing. This has been suggested to the Legislature.

Panel Member: I would like to concur with much of what is being said. I think there is no substitute for opportunities for developers and communities to talk informally with each other before they get into the formal process. There is so much about the formal process that is geared to provide a solid case in the event there is future litigation. The influence of that potential prospect reverberates throughout the whole formal system so that anything that can be done to provide for informal discussions without a mediator and over coffee and in any fashion is going to do a great deal to help. Secondly, I think there is, as Dr. Knox suggested, some really creative thought that can be given to the way formal proceedings, administrative and others, can be expanded or adjusted to include opportunities for settlement conferences, early discussions, and meetings between parties to discuss things before they get highly formalized. I think there is great opportunity for this kind of thing and very little yet done. In many ways the whole mediation movement may be a response to an over-developed formalism in our decision-making process and I think ultimately it is the process itself that has to be adjusted, modified and expanded to offer more informal exchange. It really is going to be the answer to a lot of these problems.

Dr. Peter Adler: So you are saying then that mediation or negotiation or structured forms of negotiation ought to be mandated? We ought to look for areas in the government processing where these things should be mandatory?

Panel Member: I think "mandatory" is the wrong way to think about it because it seems to me it ignores the truism that has been emerging that each dispute requires a certain degree of tailoring of the discussions and the process that it uses. So I think that making any particular thing mandatory runs the risk of becoming as formalized and almost legalistic as some of the systems we now have. Creating opportunities where people of good will can have a discussion that they might find awkward to initiate themselves on a voluntary basis, would be a vast improvement over what we now have and a great help.

Mr. Kenneth Kupchak: I want to bring to your attention a situation with geothermal and the lack of any organized method of dealing with our disputes there. Several times during the process, I had requested settlement conferences. It was something I was familiar with in the court system, Judge Pence happens to be one of the past masters in settlement conference work. But the Land Board felt that it was not empowered to conduct such conferences; therefore, it was left to the developer and our clients to try to find their own way. As early as last spring, (Peter is well aware of this) I was pleading for an opportunity to sit down at the table, any table, any shape, with the people on the other side of the dispute so we could share our mutual interest and see if it could be resolved. We went five or six months without anybody even meeting. Finally, contested case hearings were coming up this fall and about three weeks ahead of time we got together. We almost solved it. We solved every piece of it except for one issue. My own feeling is, had we started earlier we'd probably would have solved all of our disputes on the geothermal issue. Because we were unable to resolve that one issue, we had to start preparing for the next contested case hearings which diverted our attention from resolution to advocacy. Now that we're starting into another round of those kinds of things it looks to me as if the end result is going to come out very close to where Campbell and ourselves were in September around the table. But we had no formal procedure. We could not involve the landlord. They didn't want to take the position that Judge Pence would take, where he sits everybody down...he takes one out, brings another back in and hoomalimali and lomilomi and whatever else you want to do...we needed that. I think we could have resolved it two years ago, perhaps, had we had some mechanism to do that.

Dr. Peter Adler: Yes, a question here?

Comment: What form of negotiation would be most practicable where there is obvious collusion between government and the developer of a project?

Dr. Peter Adler: Does someone wants to respond to that?

Panel Member: I have to be careful in my answer to this because in a sense the question is framed in such a way as to invite the respondent to condone collusion. The question was "What type of negotiation would be advisable in a situation where there is some degree of collusion between government and the proponent of a project?"

Let me come at that in another way, which is to say I think it's absolutely essential for anyone in that situation faced with what they perceive and even if at this point it's only a perception, it's an allegation. We don't know for sure that there's something like that going on. It would be very important for anyone who would consider negotiation in that situation to insist that the first round of negotiations be on the process itself rather than on any substantive issue; that is, it would be a mistake to go immediately to the particulars of the issue of the case involved without first raising questions about the authorization, the representation, the coalitions that are going to be involved and in effect raise that up for discussion, examination and negotiation first.

Dr. Peter Adler: Question here.

Speaker from the Audience: Yes, my name is Brian Takeda. I'm at the Department of Urban and Regional Planning at the University of Hawaii. My question is addressed to a specific instance where negotiation is or is not appropriate. Specifically in H-Power, for those of you who have worked with that, why did you feel that H-Power was not amenable to negotiation techniques?

Dr. Peter Adler: Mr. St. John, do you want to address that?

Mr. George St. John: I think you're referring to my remark earlier that perhaps it wasn't something that could be negotiated. My understanding of the community's position was that none of the proposals that were put forth to modify the plan was acceptable, that the simple location of the plant in any form whatsoever in that community was unacceptable. My perception of their position was, it was not negotiable. Finally, I took them at their word. So in that case I believe it was an issue that was described earlier; it was not something that you could modify. You couldn't paint it blue or paint it green. There was no room for compromise. In the process of trying to locate the facility in Waipahu, several modifications to the plant were put forward. In one, the power plant and the processing facility were located separately. In another, modifications were made in the routing. Those types of proposals were put forward. But I do believe there is a situation where a legitimate difference of opinion as to what should or shouldn't be, can arise and the plant is either going to exist or it's not. And in that case, I believe these people genuinely believed that that it was just the wrong location for a facility of that type in any form. We were quite willing to negotiate and modify but I don't believe there was any modification that the citizens in this case were willing to accept.

Dr. Peter Adler: Thank you. Dr. Matteson, I noticed that you were shaking your head at the same time and I wondered if you had any comments?

Mr. David Matteson: No, I was going to ask a question on the H-Power one. What would have happened if really early in the process you had begun a kind of joint fact finding with Waipahu Community Association and other representatives in that area, whereby it wasn't you who would be coming in and saying that there would be fewer trucks in the area, but that jointly you had together discovered that there would be fewer trucks coming into Waipahu with H-Power. That is an example. What would have happened if two or three years before Waipahu was announced as the site, if there been that kind of joint exploration of the consequences and impacts of H-Power?

Mr. George St. John: Well, I still believe in the tooth fairy, so perhaps it would've worked. The facts in this case were that the project was put out to bid by the City and County of Honolulu. Each of the proposers was free to suggest the site at which his proposal would be located. In fact, we bid both Campbell Industrial Park and Waipahu and I believe there was also another bid located at the site of the existing incinerator. So in this particular case, the site was located primarily although not exclusively on economic considerations . The site's actual location was not known until after the bids were in because of the necessary purchasing procedures. That is, perhaps, an unfortunate set of circumstances, but the City is required to go through a purchasing procedure. In that case, I think the City was wise in trying not to pre-engineer the facility because they recognized they lacked the expertise. This purchasing procedure is not unusual; it is used in many cases where a very complex system is being purchased. But I believe your point is well taken in that if the people in all three communities, were polled and they discovered that yes, overall it would be an improvement, that the technique might have worked. Certainly the one that was employed was not successful. So there's always a better way to do things and I think this is where this new profession comes in, although I don't want to substitute mediators for attorneys. I tend to agree with Mr. Kono, though, in thinking that the legal profession does have to examine their own house to a certain extent and I don't advocate that we substitute one additional step for another. But perhaps doing something like this in advance is the way to do it. I certainly don't want to sound negative, but am trying to be realistic. I don't think three years prior to the controversy, anyone was sure that H-Power would ever become a reality; the legislation permitting it wasn't in place. But, nevertheless, I believe that you can do more. In fact one of the very first things I put down in the notes I was taking today is, "more information sooner." I think that is the message that I learned and I think perhaps the involvement of more professionalism and more professionals being involved would have helped.

Dr. Peter Adler: We have time for two last, very fast comments. I'm going to let Mr. Kono go first and then David Matteson.

Mr. Hideto Kono: We've been talking about past conflicts. I'd like to bring it home to my commission, the Public Utilities Commission, and discuss what is anticipated for a conflict in the future. Especially since I have your energy experts and energy people here. As you know, the State has a policy of promoting alternate energy. Right now any producer of electricity would be given the avoided cost pricing. But often, especially as the oil prices are going down, the new facility that uses natural energy may not be economically justified. We know very well that down the line, maybe in 1990, maybe in the year 2000 or beyond, oil prices are likely to go up. So at this moment where facilities like the H-Power which will be generating 50 megawatts of power are concerned, the question is would the community be willing to pay a slightly higher electricity cost right now so that we will have the plant in place when we need a producing unit that will not use expensive Middle East and other oil? For example, if the avoided cost now is 6-1/2 cents and there is a request for 7 cents, that means half a cent increase per kilowatt. A family using 600 kilowatts a month will be paying $3.00 more and in a year that amounts to $36.00. The question is, will members of the community and their leaders be coming forward to say "Why should we pay $3.00 more a month?" Would we be able to have people understand the broad picture, the need for each one of us sacrifice slightly now so that down the line we and our children or grandchildren will have the facility there, to not have to pay for expensive electricity? I don't know how it's going to turn out. But I'd like to see a resolution of this with the acceptance of a community. Where the mediators come in, I'm not so sure. But if we make a decision which is not to the liking of the minority or a dissenting group, it will go to court and it will take years and years for resolution. Meanwhile, the plant just sits there or will never have a chance to materialize. I just want to pose this as one of the future problems that we face.

Dr. Peter Adler: David, last comment.

Mr. David Matteson: I had the feeling part of the comment was directed at me. I'll make it short and just highlight two reasons why I think the H-Power thing would have had difficulty being mediated. By the time it became a real major public issue, people were so entrenched, as you were saying, that it was non-negotiable. Partly because a consistent pattern for decision-making in our community is "Let's make sure it's economically viable first, then choose the site based on economics and then let's ask the community how they feel about that." Those do not have to happen in a linear fashion but because bids went out for several sites, the site was selected for economic reasons and then we went to the community. Those two events could have happened simultaneously. There is a siting law in Massachusetts which says that communities can participate in site selection on their own basis and that their input can be put into the economic decision. But I think the moment the City said, "We are picking Waipahu as the site. How do you feel about that?" people were automatically put on the defensive. My other point would be that I think it's difficult to have an open, honest, unconfused, uncluttered conversation in an election year.

Dr. Peter Adler: My job right now is to bring this to a close and get all of us to lunch. There's a saying from Ambrose Bierce in The Devil's Dictionary which was written in the 1850's. He said that litigation is a machine in which you go in as a pig and you come out as a sausage. I asked a law clerk in Professor Barkai's law class the other day about what might the goals be of the alternative dispute resolution. One of the students said the goal is for the pig to go in and come out as a pig. So with that, why don't we adjourn...we'll take ten minutes and then have some lunch and then listen to Chief Justice Lum. Thank you.

THE DISCIPLINE OF CONFLICT RESOLUTION

The Honorable Herman T.F. Lum
Chief Justice
State of Hawaii

Let me begin by congratulating and thanking you for your interest in examining the discipline of conflict resolution. I feel strongly that this is an idea whose time has come. Indeed the time has never been more ripe, more appropriate for looking for new ways to approach the age-old problem of settling disputes to the satisfaction of all concerned parties. That itself is a critical concept: the satisfaction of all parties. We all know that the resolution of disputes does not always lead to satisfaction for everyone involved.

It is clear that methods of conflict resolution, in their many forms, fall into two categories: adversarial and consensual. The adversarial path seldom yields satisfaction when the parties have literally fought it out to the end result of one winner and one loser, or, one winner and several losers, when there happen to be more than two parties involved. The consensual path, on the other hand, leads to the potential satisfaction of all the parties, especially because this method encourages the search for as many "winners" as possible.

Let me give you examples of these two scenarios. The first is the typical adversarial resolution, which may or may not bring about satisfactory results.

McBryde v. Robinson -- the so-called water rights case -- has languished in our courts for nearly 25 years, forcing one of the lawyers to quip: "I've spent a lifetime on that case." After 25 years, the case has not become final because it now is pending before the U.S. Supreme Court. Even after its legal finality, the proposed water code, if enacted, will result in other litigation.

After eight years, the Ninth Circuit put a stop to H-3. The result may have been satisfactory to the opponents but hardly satisfactory to the government in view of the enormous economic and other costs.

Nukoli'i is another example. It took six years to wind its way through the courts and eventually to a conclusion.

Hui Alaloa v. Planning Commission has again made news. Those opposing the construction of a new hotel on Molokai have filed yet another appeal, after the Hawaii Supreme Court had sent the case back to the Planning Commission for a rehearing. The first litigation took all of five years. In other land use permit cases we have heard, the time frame to bring litigation to a final decision by the Supreme Court has generally run between four and five years.

Now consider the other scenario. Under Supreme Court rule, the court may order a prehearing conference before argument.

In one case, involving construction of a waste disposal plant, I acted on behalf of the court as the presiding justice. During the conference, I learned that people in the subdivision below the plant were concerned about their own safety, and the safety of their water table, in case of leakage. The parties were distrustful of each other and had little communication. I sat as mediator and "forced" the exchange of information, which eventually resulted in a satisfactory settlement to all parties.

In one scenario, you had waste in terms of time, energy and economic resource. In the other, you avoided such waste, although admittedly settlement could have been reached at a far earlier date, but purportedly satisfaction was reached by all sides.

I have a special interest in the study of conflict resolution, not simply because I am administratively in charge of the primary institution of conflict resolution in the State but because the courts and those who interact with them have a tremendous stake in the exploration of alternatives to litigation for the resolution of disputes.

Today, the courts are flooded with civil litigation, and more and more the courts themselves complain of being unprepared and inadequate to deal with such an unmanageable workload. Even if nothing can be done to solve the peculiarly American problem of increasing contentiousness, then at least alternatives can be sought to handle this situation of reliance upon the courts for resolving disputes. At the same time, resolution of disputes must be geared toward the satisfaction of all participating parties. I believe that this goal has lost some potency as the litigation explosion has gained strength.

In recent times our society has come to believe that lawyers, like doctors, are professionals whom we can trust to "make everything right" for us. Consequently, litigation is seen as a "cure-all" for many social problems. Let me repeat: I believe that the future of dispute resolution lies with finding and implementing alternative forums to help resolve some of the disputes we are now dealing with in the courts, as well as some that have not yet been invented. And I do believe we are well on our way to finding those alternatives and institutionalizing them.

This morning you have discussed disputes and various pathways to resolution. Recently, the Judiciary has also been working to find alternatives to litigation that will result in greater efficiency within the courts and greater satisfaction for the disputants. Let me briefly outline some of the efforts to develop and implement these alternatives within the Hawaii Judicial System.

Case backlog and trial delay are twin monsters that have plagued the Hawaii Judiciary for several years. Indeed, they are probably the most significant problems faced by our judicial system. Over the past three years it has been my number one priority to cut into backlog and delay, allowing the court calendars to become current, hence more efficient. One of the methods we have used to achieve this is a master calendaring system, employed by the First Circuit Court. The First Circuit encompasses metropolitan Honolulu and bears about 80 percent of the State's caseload. The system is intended to cut into our backlog, reducing the time lapsed between filing and disposition.

Master calendaring is managed by two administrative judges, Judges Chun and Chang, who respectively head the Civil and Criminal Divisions. Instead of controlling their own individual calendars -- a system which in the past sometimes resulted in unavoidable delays -- trial judges now report the completion of each case to the administrative judge; the administrative judge then immediately assigns a new case for hearing, and no time is lost. Additionally, the calendar has been augmented by other available resources, such as simplified forms and other streamlined case management procedures.

It is important to keep in mind that these efforts are the direct result of what I believe is an unnecessarily heavy caseload. Total case filings in Hawaii today stand at a figure in excess of 60,000. It is also a fact that fully 90 percent of the civil cases filed are settled before they ever go to trial. If this is so, why not make every effort to keep them from getting on a track that will lead to their cluttering up the docket at all? This is why I think it is so important to involve the courts in Alternative Dispute Resolution (ADR) which is what we have endeavored to do.

Over the past four years, the Judiciary has supported ADR by encouraging development of neighborhood mediation centers and by pioneering the use of mediators for many types of family disputes. In February of last year, I committed the Judiciary to a far stronger role in this area by establishing a Judiciary Program on Alternative Dispute Resolution. With grant support from the National Institute for Dispute Resolution (NIDR), Hawaii became one of five States in the country to launch a more comprehensive and State-level coordinating initiative aimed at broadening the acceptance of mediation and arbitration. Our program, which will continue into the next year, has three general objectives:

(1) To gather and disseminate up-to-date information on alternative dispute resolution methods;

(2) To explore, test and evaluate new uses for mediation and arbitration; and

(3) To help institutionalize the use of these methods in the courthouse, in our corporations, and in the community at large.

Additionally, the Judiciary has introduced or intends to introduce other projects in the field of ADR which will have some potentially far-reaching effects. The first of these projects -- in fact, officially launched just last week -- is a "court arbitration" program that will require parties in certain types of civil cases to use arbitrators. Briefly stated, this effort will involve four important features:

-- An early and mandatory arbitration for certain types of civil cases below a particular dollar threshold;

-- The use of experienced and skilled attorneys as court-appointed arbitrators;

-- The right of either side to appeal an award and receive a trial De Novo; and

-- Certain disincentives that the court may impose for not doing better than the arbitration award at trial.

Sixteen State and Federal jurisdictions are currently experimenting or using this type of arbitration; Hawaii is the seventeenth. Hawaii may well become the first jurisdiction in the country to use such a process on a statewide basis. The basic purpose of this program, of course, is to provide a fair, just and satisfying procedure that expedites lower value cases to earlier resolution. To accomplish this, over 250 arbitrators have been appointed to arbitrate personal injury cases with a probable award value of $50,000 or less. Very quickly we expect to expand arbitration to many other types of civil matters.

The Judiciary also plans to establish a set of suggested standards and guidelines for persons serving as mediators in the State of Hawaii. Also, there is yet another application of ADR that will be taking place at the courts in the near future. The Judiciary's program on ADR has been conducting background research on the civil settlement process in Hawaii. Since negotiated settlement is a common phenomenon, and comparatively few cases actually go to trial, judges often play an important mediative role in settlement conferences routinely scheduled a month before trial. To enhance this activity, I will be establishing a training course on "Judicial Mediation" to be offered to Hawaii's civil judges this spring.

All of these projects are geared toward a concept which has been referred to as the "multi-door courthouse." This concept stems from an understanding that parties to disputes can no longer be forced, by lawyers or judges, to solve those disputes using only the traditional method of adjudication. People and institutions involved in disputes want and need alternatives that allow them the optimal advantages and benefits in resolution. In short, because a "win-win strategy" of negotiation is believed to be more beneficial to all disputing parties than the "win-lose" strategy of adjudication, attorneys and the courts must learn to become less adversarial in their work, and more consensual. This carries over, I believe, to social disputes of many kinds, including environmental, land use and energy siting, which you have discussed today. All of you are aware of just how important these matters truly are. Often they involve major value choices that we must make now and that will unquestionably affect future, yet-to-be-born generations. Sometimes the outcomes of these disputes are irrevocable. It is hard to "unbuild" a building once it has been built. Once an endangered species is gone, we cannot recreate it.

Let me say that the court is not always in the best position to solve these problems. In general, the problem stems from ambiguities in the statutes, ambiguities purportedly caused because (1) the policy makers purposely created such ambiguities, generally stemming from their refusal to make hard political decisions; (2) the inherent ambiguous nature of the English language, hence the inability to state precisely what is intended; and (3) of lacunae, where the statutes fail to address the problem in question. There is a vacuum in the statute. The problem is not covered by statute since it is difficult to foresee all of the problems.

Ambiguities force the courts to interpret the statute -- to determine the intent of the policy makers -- and, quite frankly, the courts are generally not in the best position to make policy decisions, as are often required. It is simply because the courts lack sufficient information to do so, which is the result of their inability to conduct public hearings to gather the facts. The result can lead to what lawyers label as "bad case makes bad laws."

Obviously, no single dispute resolution agency in our society is capable of settling all such matters all the time. Disputes over developments like the H-3 Freeway, Nukoli'i or geothermal energy on the Big Island involve important social issues. We have all witnessed how the opposing sides in these disputes -- and sometimes there are many more than two of them -- have pressed their issues in different arenas simultaneously. Thus, we often see energy and land use conflicts "circulating" through the courts, through the Legislature and through administrative agencies simultaneously, defying the ability of any one agency to resolve them.

American society in general -- and our Island society in particular -- must find better ways of tackling these issues. Perhaps the challenge now is to begin thinking together and to try to invent new methods that save time, save money and that allow all of us a chance to win. Regardless of which side we might represent in a given land use or energy dispute, I suspect we all share a belief that the adversarial decision-making mechanisms now available to us are an insufficient set of options for conflict resolution. Perhaps we also need to re-think our more fundamental ideas about what public policy and facility-siting conflicts are all about. Conflicts, after all, can create opportunities for individuals and groups to come together and clarify their goals and values. Conflicts offer us opportunities to educate each other about what is important for the future. Conflicts also present opportunities for dialogue, for discussion, for negotiation and for cooperative problem solving.

Let me end by reiterating what I think has been one of this morning's major themes. We need to find better ways of disagreeing with each other; that is, to find methods of conflict resolution that don't increase the social and economic costs already implicit in the disagreements themselves. We must continue to develop and test the use of mediation and arbitration as alternatives to adjudication.

The Hawaii Judiciary is committed to this challenge and commends the efforts that all of you are making in the area. I encourage you to think together on these matters, to be inventive, and to begin the task at hand: finding better ways of handling differences of opinion. I believe that Hawaii's future may very well depend on the success of your leadership.

APPENDIX: REGISTRATION LIST

REGISTRATION LIST

SEMINAR ON CONFLICT RESOLUTION FOR ENERGY SITING AND LAND USE
Sheraton-Waikiki Hotel, Honolulu, Hawaii February 18, 1986

STATE GOVERNMENT

ARAKAWA, Milton, Hawaii Community Development Authority, DPED
BARLOW, Robert, Energy Division, DPED
BECK, Andrea, Energy Extension Services Office, DPED
CHANG, Diana, Legislative Auditor's Office
CHING, Anthony, Planning Division, DPED
CHRISTENSEN, Carl, Legislative Aide, Rep. Bill Pfeil
EDMUNDS, Sallie, Dept. of Urban & Regional Planning, University of Hawaii
FUJIMOTO, Howard, Planning Division, DPED
FUJIMOTO, Tatsuo, Land Use Division, DPED
HARRIS, Alfred, Consultant, DPED
HEE, Robert, Planning Division, DPED
HENRY, Edward, Planning Division, DPED
HIGGINS, E. Chipman, HNEI, University of Hawaii
KADOOKA, Kim, Planning Division, DPED
KAMALI'I, Kina'u, State Representative
KANE, Bartholomew, State Librarian
KAWAKAMI, Richard, Energy Division, DPED
KIM, Vickie, Information Office, DPED
KUBACKI, Joseph, Energy Division, DPED
LAPILIO, Joseph, Administrative Assistant, Governor's Office
LEONARD, Jaime, Energy Division, DPED
LESPERANCE, Gerald, Energy Division, DPED
LIM, Michael, Planning Division, DPED
MARCUS, Edgar, Planning Division, DPED
MATSUURA, Richard, State Senator
MERCE, Marian, Legislative Auditor's Office
MERRIAM, Robert, Forestry Division, Dept. of Land & Natural Resources
MOREAU, James, Energy Division, DPED
NISHIDA, Jean, Land Use Division, DPED
NISHIMOTO, Melvin, Hawaii Community Development Authority, DPED
O'BRIEN, Thomas, Energy Division, DPED
PEREZ, Albert, Dept. of Urban & Regional Planning, University of Hawaii
ROGOFF, Edward, Planning & Management Division, Dept. of Budget & Finance
ROSEHILL, Linda, Deputy Director, DPED
SAGATIS, Lois, Energy Division, DPED
SAKAMOTO, Roy, Office of Environmental Quality Control, Dept. of Health
SHON, Carilyn, Energy Division, DPED
SOARES, Buddy, State Senator
TAKAHASHI, Karen, Program on Alternate Dispute Resolution, The Judiciary
TAKEDA, Brian, Dept. of Urban & Regional Planning, University of Hawaii
TASAKA, Craig, Planning Division, DPED
TOM, Clayton, Student, University of Hawaii
TOYAMA, Susan, Planning & Management Division, Department of Budget & Finance
WOODRUFF, James, Hawaii Natural Energy Institute, University of Hawaii
ZAIGER, Maia, Energy Division, DPED

FEDERAL GOVERNMENT

HARRISON, John, National Marine Fisheries Service, NOAA
SHUPE, John, U.S. Dept. of Energy, Pacific Site Office

COUNTY GOVERNMENT

BLANCHARD, William, Economic Development Department, County of Kauai
BLYTH, Cheryl, Hawaii County Council
BORNHORST, Marilyn, City and County of Honolulu Council
EVANS, Mary Alice, Honolulu Planning Commission, City and County of Honolulu
KOKUBUN, Russell, Hawaii County Council
MELTON, Richard, City and County of Honolulu, Council Staff
NISHIMURA, Brian, Planning Department, County of Hawaii
PIIANAIA, Ilima, Planning Department, County of Hawaii
SOBIN, Judy, City and County of Honolulu, Council Staff

PRIVATE INDUSTRY

BEATON, William, TRB Hawaii
BONNET, William, HDWC Program Manager, Hawaiian Electric Company
DAMRON, Ted, Hawaiian Electric Company
DANGLER, Diane & Tim, Dynasoar, Inc.
ERICKSON, Jackie, Hawaiian Electric Company
GRING, Pam, Belt, Collins & Associates
HARRISON, Craig, Goodsill, Anderson, Quinn & Stifell
JOHNSTON, Wallace, Hawaiian Electric Company
KEALA, Samuel, Estate of James Campbell
KRASNICK, George, Parsons Hawaii
LEE, Howard, Gasco, Inc.
LOPEZ, Louis, Hawaiian Dredging and Construction Company
MANSUR, Juliane, Parsons Hawaii
McHALE, Frank, Hawaiian Dredging and Construction Company
MUNGER, Brenner, Hawaiian Electric Company
PATTERSON, Ralph, Thermal Power Company
PECK, James, Hawaiian Electric Company
POLOSKY, Dennis, Citizens Utilities Company, Kauai Electric Division
YOUNG, Peter, Real Estate Works Hawaii, Kailua-Kona

PUBLIC

AMERDING, L., Western Temporary Services, Inc.
BARKAI, John, Student, Law School, University of Hawaii
CHANG, Leland, Neighborhood Justice Center
CHAPMAN, Gordon, Consultant
CHILDERS, Robert, Student
CLINE, Roger, Building Dept., Sioux Falls, South Dakota
DASIELL, Gene
DAVENPORT, Joan, League of Women Voters
DINELL, Christi, Office for Catholic Social Ministry

PUBLIC (Continued)

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BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift Zone, as a Geothermal Resource Subzone	GS No. 9/26/85-5

PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

CERTIFICATE OF SERVICE

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BACKGROUND

1.1 Subject

a. This matter concerns the designation of approximately 11,745 acres in the Kilauea Middle East Rift Zone, Island Of Hawaii, as a geothermal resource subzone.

1.2 Description of Area

a. The proposed area for designation as a geothermal resource subzone is delineated on State Exhibits 2, pp. 5, 31, 34, 35 and 37, and Exhibit 4 and consists of approximately 11,745 acres and is located in the area known as the Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve.

1.3 Jurisdiction of the Board of Land and Natural Resources

a. Act 296, SLH 1983 designated the Board of Land and Natural Resources (BLNR) with the responsiblity for designating geothermal resource subzones in the State of Hawaii. The procedural structure of Act 296 establishes that the designation of geothermal resource subzones would

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PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

BACKGROUND

1.1 Subject

a. This matter concerns the designation of approximately 11,745 acres in the Kilauea Middle East Rift Zone, Island Of Hawaii, as a geothermal resource subzone.

1.2 Description of Area

a. The proposed area for designation as a geothermal resource subzone is delineated on State Exhibits 2, pp. 5, 31, 34, 35 and 37, and Exhibit 4 and consists of approximately 11,745 acres and is located in the area known as the Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve.

1.3 Jurisdiction of the Board of Land and Natural Resources

a. Act 296, SLH 1983 designated the Board of Land and Natural Resources (BLNR) with the responsiblity for designating geothermal resource subzones in the State of Hawaii. The procedural structure of Act 296 establishes that the designation of geothermal resource subzones would be the first step of a two-step process. The second step of the process would be the actual approval of a specific project at a specific site within a designated geothermal resource subzone.

b. Additionally, the proposed subzone of approximately 11,745 acres in Puna, Hawaii, falls within the limited (P) subzone, over which the BLNR has exclusive jurisdiction.

c. The contested case hearing conducted by the BLNR to consider the designation of approximately 11,745 acres of the Middle East Rift Zone as a geothermal resource subzone is not required by Act 296 but was conducted by the BLNR pursuant to its discretionary authority for purposes of gathering additional information to assist the Board in the subzone designation process. The Hawaii State Legislature, in passing upon the final wording of Act 196, expressly provided that the BLNR would conduct the subzone designation analysis and then recommend areas it considerd as appropriate geothermal resource subzones to the public through the public hearing process to obtain the public's views of the Board's proposal. See Section 205-5.1(b), 5.2(c)(d), HRS.

d. A definite and uncontrovertable indication of the legislative intent that the subzone designation process is a rule-making proceeding is Conference Committee Report

Number 56, dated April 19, 1983, which accompanied Senate Bill Number 903, Senate Draft 1, House Draft 2, Conference Draft 1. Senate Bill 903 ultimately became Act 296 after passage by the Legislature. The Conference Committee Report on page 1, last paragraph reads:

> It is your Committee's intention that the Land Board designate subzones pursuant to its rule-making procedures and thereafter all geothermal activities within the subzones shall be governed by all currently applicable statutes, including Chapter 183, 205A, 226 and 343. (Emphasis added).

CHRONOLOGY - FINDINGS OF FACT ON PROCEDURAL HISTORY:

1. On March 2, 1982, the Estate of James Campbell ("Campbell") filed with the BLNR, a Conservation District Use Application (CDUA) to develop geothermal resources at Kahauale'a, Hawaii.

2. On May 6, 1982, Campbell filed with the BLNR and the Environmental Quality Commission a Draft Environmental Impact Statement in support of its CDUA.

3. On May 20, 1982, the BLNR announced that the CDUA would be conducted as a contested case hearing.

4. On October 25 through 29, 1982, November 15 through 19, 1982, and December 7, through 10, 1982, the BLNR conducted quasi-judicial "contested case" proceedings regarding the CDUA pursuant to the Hawaii Administrative Procedure Act, Chapter 91, HRS, and the BLNR's Rules of

Practice and Procedure. The Volcano Community Association ("VCA") was a party to said proceeding.

5. The BLNR by its Findings Of Fact and Conclusions Of Law and Decision and Order dated February 25, 1982, granted Campbell specific exploration rights on the subject parcel under CDUA No. HA 3/2/82-1463.

6. Subsequent to the rendering of the Decision referenced above, the Hawaii State Legislature passed Act 296, SLH 198, delegating the Board of Land and Natural Resources the responsibility for designating geothermal resource subzones and selecting those areas that can best demonstrate an acceptable balance among the criteria set forth in said act.

7. The designation of geothermal resource subzone areas would only be the first step of a two-step process. After the designation of a geothermal resource subzone, any person who wished to build a geothermal project at a specific site would, as a second step, apply to the Board of Land and Natural Resources or the appropriate county agency for authority to develop a specific project at a specific site. This second step would be conducted as a contested case if a request for such a hearing was made.

8. Pursuant to Act 296, SLH 1983, the Chairperson of the BLNR assigned the task of recommending geothermal

resource subzone areas to the Division of Water and Land Development (DOWALD), State of Hawaii.

9. DOWALD began work on the subzone process after June 14, 1983, when Governor George Ariyoshi signed Act 296, SLH 183 into law.

10. A Plan Of Study was devised by DOWALD as an outline by which to assess the various potential areas in view of the criteria specified in Act 296. The principle elements of this strategy included a literature review of available information, and an assessment of the following factors:

* Potential geothermal energy production
* Use of geothermal energy in the area
* Geologic Hazards
* Social and Environmental Impacts
* Compatability with present and planned use
* Potential economic benefits
* Compatability with conservation principles where a subzone falls within a conservation district

11. The 1984 Legislature enacted Act 511, which in part gave first priority to the assessment of Kahauale'a as a geothermal resource subzone. The BLNR was required to act on said designation by December 31, 1984.

12. Included in the designation process was a public information and participation effort to elicit

community concerns. Included in this process was a meeting held on July 11, 1984, in the Volcano Community on the Big Island.

13. At that public hearing requests for a contested case hearing on the designation of 5,300 acres of Kahauale'a, Puna, Hawaii, were made to the Land Board.

14. Pursuant to these requests, the Board of Land and Natural Resources, under their discretionary power, decided to hold a contested case hearing, reserving the right to litigate at a later time, the issue of whether it was mandatory or not to hold a contested case hearing for the designation of geothermal resource subzones.

15. On December 12, 13, 15, 16, 18, 19, the BLNR conducted quasi-judicial "contested case" proceedings regarding the designation of 5,300 acres of Kahauale'a, Puna, Hawaii, as a geothermal resource subzone pursuant to the Hawaii Administrative Procedure Act, Chapter 91, HRS, and the BLNR's Rules of Practice and Procedure. All intervening parties were given the opportunity to present witnesses and evidence, cross-examine witnesses and present rebuttal evidence.

16. On December 28, 1984, the DLNR issued its Decision and Order on the Proposed Geothermal Resources Subzone at Kahauale'a, Hawaii.

17. In part, the Decision and Order stated that the State of Hawaii formally requested that "the Estate of James Campbell investigate and consider a land exchange involving State owned land in Kilauea Middle East Rift Zone and Campbell Estate's lands at Kahauale'a (Excluding Tract 22) . . . ."

18. The Decision and Order also stated: "The Board of Land and Natural Resources on its own motion hereby directs the Division of Water and Land Development (DOWALD) of the Department of Land and Natural Resources (DLNR) to immediately undertake and conduct an assessment of the Kilauea middle east rift zone in and adjacent to the Natural Area Reserve beginning on the western boundary of the Kamaili geothermal subzone as a potential geothermal resource subzone. Although this area had not previously been evaluated due to its classification as a Natural Area Reserve, the Board now believes that the area should be reviewed.

If (a) the assessment of the Kilauea middle east rift zone does not result in a designation as a geothermal resource subzone in this area; or (b) a land exchange between the State of Hawaii and the Estate of James Campbell is not consummated then the remainder of the 5300 acres proposed by DOWALD as a geothermal resource subzone in Kahauale'a heretofore not designated by this Decision and

Order shall be and is hereby ordered to be so designated as a geothermal resource subzone."

19. Pursuant to the Decision and Order, DOWALD, on its own, held four (4) public information meetings. The dates and places of these meetings are listed below:

March 13, 1985	-	Keeau, Hawaii
March 14, 1985	-	Pahala, Hawaii
May 15, 1985	-	Pahoa, Hawaii
May 16, 1985	-	Pahala, Hawaii

20. The BLNR held a public hearing on September 26, 1985, to elicit community concerns.

21. At the last public hearing, requests for a contested case hearing on the designation of approximately 11,745 acres at the Kilauea Middle East Rift Zone were made.

22. On October 16, 1985, the BLNR announced that a contested case hearing would be held on November 13, 1985, concerning the designation of approximately 11,745 acres in and adjacent to Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve.

23. On November 1, 1985, a prehearing conference was held at the DOWALD conference room in Honolulu, Hawaii. At that time, DOWALD, Mae Evelyn Mull, Karl and Melissa Kirkendall, Frederick Warshauer, John L. Perriera, Susan Carey, Diane Ley, Volcano Community Association, Lehua Lopez, Eva Lee, Louis Whiteaker, Chiu, Leong, Virginia B. MacDonald, Debra Hopson, Ann Markham, Mike Markham, Beverly

MacCallum, Matt Luera, Hawaii Audubon Society and Sierra Club, Hawaii Chapter, were accepted as parties to the contested case, while the Estate of James Campbell and the True/Mid-Pacific Geothermal Venture were admitted as intervenors. The intervention status of Palikapu Dedman and Emmet Aluli were still under consideration by the BLNR.

24. On November 7, 1985, a second prehearing conference was held at the DOWALD conference room. At that time, the Estate of James Campbell and the True/Mid-Pacific Venture continued its objection on the necessity of having a contested case hearing held for the subzone designation process. The Motion was denied on the same grounds, with the understanding that this hearing was being held pursuant to the discretionary authority of the Board with the further understanding that the denial does not constitute a decision by the Board and that the contested case hearing is or is not required.

25. On November 13, 1985, Palikapu Dedman and Emmet Aluli were granted intervenor status in the hearing.

26. On November 13, 14, and 15, 1985, the BLNR conducted quasi-judicial "contested case" proceedings regarding the designation of approximately 11,745 acres in the Kilauea Middle East Rift Zone, Island of Hawaii, as a geothermal resource subzone pursuant to the Hawaii

Administrative Procedures Act, Chapter 91, HRS, and the BLNR Rules of Practice and Procedure. All parties and intervenors were given the opportunity to present witnesses and present rebuttal evidence.

PROPOSED FINDINGS OF FACT ON REQUIREMENTS UNDER ACT 296

A. Location and Size of Proposed Subzone

A.1 Location.

1. The area, located between the western boundary of the Kamaili geothermal resource subzone and the eastern boundary of Kahauale'a, was examined for resource potential and evaluations were made on geologic hazards, social, economic, and environmental impacts, and compatability of geothermal development. The potential geothermal resource area was evaluated on the basis of potential and real impacts which may occur within the identified area and in consideration of statutory state energy objectives and policies.

Based on the assessment factors above, the proposed Kilauea middle east rift GRS boundaries were determined as follows:

-- Almost all of the land area contained in the proposed GRS is within the 90% probability area.

-- GRS boundaries were determined by utilizing existing metes and bounds where possible, to clearly define subzone limits.

-- The eastern boundary abuts the existing Kamaili GRS, straddling the 90% probability band and forming a contiguous land use designation. The Board, in the Decision and Order had directed the Division to assess the Kilauea Middle EaAst Rift Zone beginning on the western boundary of the Kamaili GRS.

-- The southern boundary closely parallels the 90% line and is limited because the resource potential of areas to the south of 90% probability line is believed to diminish with distance from the rift zone. Also, permeability in areas south of the rift zone is expected to be low as a result of mineral deposition from salt water intrusion. Potential hazards from lava flows are greater south of the rift zone due to the southward sloping contour of the land. Also, earthquakes are relatively more frequent south of the rift zone.

-- The western boundary was determined assuming that Kahauale'a is designated as a natural area reserve. The boundary provides a 2000-foot buffer between the GRS and Kahauale'a to mitigate any possible effects on the prime native forest and wildlife at Kahauale'a.

-- The northern GRS boundary was determined a reasonable distance from the rift zone to provide areas less susceptible to lava flow hazards. It is anticipated that powerplants may be sited on locally elevated ground in these safer northern areas.

(Written testimony, Tagamori, pp. 19-20)

2. The Developer has requested that a strip approximately 2,000 feet wide located along the southern boundary of the proposed subzone be exchanged for a comparable area along the northern boundary. The relative resource value of the two areas are equal, but the hazard risk is much less to the north.

3. The modification offered by Campbell/True/Mid-Pacific Venture on Campbell Exhibit 3 is a reasonable modification, although removing part of the southern boundary would also mean losing some geothermal potential, but not at an extreme loss as the potential drops off rapidly to the south. The north boundary offers an area of lower geologic hazard, which is a reasonable gain in the exchange. (Don Thomas, Tr. Vol. IV, p. 172).

4. That no objection was made to moving the boundary of the subzone to the north.

A.2 <u>Size</u>

1. The total area of the proposed GRS is about 11,745 acres. This area is reasonable for geothermal development because of the resource risk involved. In the California Geysers, an area of 1,000 acres is required to support a 110 MW power plant; however, in the Kilauea East Rift Zone more acreage may be needed depending on site specific conditions such as average well output and injection requirements. (Campbell Exh. 1, p. 9).

2. The USGS has estimated that the Kapoho Reservoir at HGPA requires 125% more acreage than the Geysers for the equivalent power output, also allowances must be made for inaccessible areas such as environmentally qualified forests, pu'us and buffer zones, leaving the actual developable acreage reduced by 30%.

Further, the probablity of finding temperatures above 125^{o}C is 90% greater than finding temperatures above 175^{o}C, the minimum for power generation is thus more likely 75%. Based on results from drilling operations in lower Puna, where two wells out of seven were successful, a 28% success factor is reasonable to expect. Combining all probabilities, total production acreage can be estimated as follows: 11,745 x (.7) x (7.5) x (.28) = 1,727 acres which is equivalent to the acreage required for a potential of 84 MW. Although the potential could be much higher, it demonstrates the necessity for allocating large land areas for subzones. (Campbell Exh. 1, p. 9, 10).

3. Geothermal development occupies very little surface area with the result that increasing the size of a subzone does not necessarily result in greater environmental impact. Thus, from a long-term planning standpoint, it may be feasible to contract all GRS's at a later date once more information is available. (Campbell Exh. 1, p. 10).

4. Geothermal is where it is found. It cannot be developed where desired. (Campbell Exh. 1, p. 11).

5. Drilling is the only way to actually confirm a geothermal resource. (Furumoto testimony, December 16, 1984, p. 180; KGS 8/27/84; Moore testimony, Vol. XI, p. 3 152, CDUA hearing).

6. There are geologic hazards associated with the entire rift zone, these hazards can best be mitigated by proper siting design and by distributing the development on the Kilauea East Rift over as broad an area as possible to minimize the risks from individual erruptions. (Written Testimony, Don Thomas, p. 2).

B. Potential Geothermal Energy Production

1. A panel of technical experts closely associated with geothermal research in Hawaii was assembled to assist DOWALD staff in identification of areas with the potential for high temperature geothermal resources. (DOWALD, Exh. 6, p. 1; KGS 8/27/84, State Exhibit 2, p. 3).

2. A "high temperature" geothermal resource is defined as one having a temperature greater than 125°C at a depth of less than 3 kilometers. (DOWALD, Exh. 6, p. 5, KGS 8/27/84, State Exhibit 2, p. 3).

3. The panel of experts identified the Kilauea East Rift Zone as an area possessing the necessary qualities for designation as a potential resource area based on:

(i) Three wells that encountered a high temperature resource with one of the three presently producing a geothermal resource;

(ii) Geophysical indicators, mainly aeromagnetic surveys, electrical surveys, microearthquake and self-potential surveys;

(iii) Geologic evidence of recent lava intrusion into the east rift zone;

(iv) Geochemical data;

(v) An aeromagnetic anomoly associated with the rift showing that temperatures in excess of 500°C were present at shallow depths in the rift;

(vi) Resistivity anomolies indicating shallow high temperature ground water; and

(vii) Other available information from public and private services.

(Chuck Testimony, p. 2-9; KGS 8/27/84 State Exh. 2, p. 3)

4. The area of the Kilauea East Rift Zone having a probability of 90% or greater chance of encountering a high temperature geothermal resource is indicated by the 90% contour line on p. 5, State Exh. 2.

5. The area of the Kilauea East Rift Zone having a probability of 25% or greater chance of encountering a high temperature geothermal resource is indicated by the 25% contour line on p. 5, State Exh. 2.

6. Between contour lines, probability increases systematically from 25% to 90%. (Vol. 22, p. 56, Dec. 19, 1984; KGS 8/27/84, State Exh. 2, p. 3).

7. According to Dr. Richard Moore's study of the geology and petrology of the Kilauea East Rift Zone which indicates that there are three (3) areas that overlie secondary magma chambers and thus, are promising geothermal targets. One is the site of the general area of HGPA, another is the Kalehua area and the third is around Heiheiahulu which is in the area of the proposed subzone. (Richard Moore, Vol. XI, p. 3108, CDUA hearing).

8. Most of the proposed 11,745 acres in the Middle East Rift Zone is located in the area designated by the Technical Committee as the area with 90% or greater probability of finding heat at depths less than 3 km. (State Exh. 2, p. 4).

9. There is no doubt that there is abundant heat stored in the rift zone. Resevoir permeability is the biggest uncertainty. Although there are no surface measurements that can be made to indicate permeability, indirect evidence such as microearthquakes, swarms and surface faults are usually reliable indicators and both surface faults and earthquakes have been documented in the area. (Campbell Exh. 1, p. 2-3).

10. The results of geothermal drilling so far in the Kamaili and Kapoho subzones have been disappointing and a rejection of the Middle East Rift Zone without assurance that the other subzones could provide the needed electrical

capacity would not be in the best interest of the Big Island. (Niimi, Tr. Vol. VI, p. 88).

C. Use of Geothermal Energy in the Area

1. Based upon prior permit applications and developer interest, the prospects for utilization of the proposed subzone for geothermal exploration and development is good. (DOWALD Exh. 1, p. 51; KGS 8/27/84).

2. The developer interest in the area was stimulated by a request for proposal (RFP) issued in 1980 by Hawaiian Electric Light Company, Inc. (HELCO) for geothermally generated electrical power to meet their projected power requirements in 1988. (DOWALD Exhibit 1, p. 30).

3. HELCO's Forecast Planning Committee predicts approximately a 2% growth load for the Island of Hawaii for the next 20 years. Based upon this 2% growth load and considering other factors such as the closing of Puna Sugar Company in early 1985, HELCO must plan for generation additions to meet this increase in growth load for the next 20 years. (Applicant's Exh. 9, p. 2; CDUA Hearing).

4. HELCO anticipates the need for an additional 13 megawatts of power in 1988, and in 1991 if unable to obtain a committment from the sugar company, HELCO would conceivably need another 13 megawatts of power, with an additional 14 megawatts of power in 1993 if the HCPC

contract is not renewed. Thus, a total of 40 megawatts of power may be needed by 1993. (Alva Nakamura, Tr. Vol. IV, p. 124, 125).

5. HELCO believes that geothermal power would hold the most promise for firm base load generation. (Alva Nakamura, Tr. Vol. IV, p. 113).

6. If West Hawaii were to develop a greater need for electricity, it is HELCO's plan to transport this electricity from East Hawaii. (Alva Nakamura, Tr. Vol. IV, p. 114).

7. If HELCO had a firm power source that was more economical than the electricity currently being put out through the use of their old generators, HELCO wants to retire those generators. (Alva Nakamura, Tr. Vol. IV, p. 126).

8. In order for the County of Hawaii to become energy self-sufficient by 1990 without the use of oil, an excess of 100 megawatts of power would be needed by that date. (Alva Nakamura, Tr. Vol. IV, p. 127).

9. The purpose of HELCO's RFP request was to encourage and implement the development of geothermally produced power generation in Hawaii so that this source of electric power would be available to fill the anticipated need for additional and more reliable electrical generating

capacity for the HELCO system by 1988 at the most favorable terms to HELCO and to HELCO's ratepayers.

10. Developer interest in geothermal exploration and development is clearly indicated on the record by Campbell/True-Mid-Pacific's BLNR's Decision on CDUA HA 3/2/82-1463 the BLNR Decision on the Kahauale'a subzone, GS 8/27/84, and by the Developer's continued participation in the subject hearing.

11. The Hawaii State Energy Plan has an objective to accelerate the transition from fossil fuel to an indigenous renewable energy economy by facilitating private sector activities to explore supply options and achieve local commercialization and application of appropriate alternate energy technologies. The designation of a geothermal subzone in the Kilauea Middle East Rift Zone would be consistent with and promote the attainment of this objective. (State Energy Plan, Applicant's Exh. 31, p. 15).

12. The establishment of the Kilauea Middle East Rift geothermal subzone is in accord with the goals and objectives of the County of Hawaii. The County's goals for energy are: 1) to strive towards energy self-sufficiency for Hawaii County; and 2) to establish the Big Island as a demonstration community for the development and use of natural energy resources.

To achieve these goals, a number of policies for County actions and/or programs are set forth. These include:

--encouraging the development of alternative energy resources and the expansion of the energy research industry;

--educating the public on new energy technologies;

--fostering attitudes and activities conducive to energy conservation;

--ensuring a proper balance between the development of alternative energy resources and the preservation of environmental fitness;

--striving to assure a sufficient energy supply for present and future demands;

--providing incentives to encourage the use of new energy sources and the promotion of energy conservation;

--seeking public and private funding for research and development of alternative energy resources; and

--coordinating energy research and development efforts of the public and private sectors.

These goals and policies clearly direct the County to explore the potential of natural energy resources in order that the island of Hawaii can strive towards energy self-sufficiency. Geothermal is one of the island's indigenous energy resources. The County recognizes that exploration and development of its potential geothermal resource will assist its overall program to develop the array of alternative energy sources on the island of Hawaii. (County Exh. 1, November 15, 1985).

13. Over 80% of the State's demand for electricity is on Oahu which lacks alternative energy resources sufficient to meet its demand. (VCA Exh. 112, preface, Subzone Hearing).

14. Although the ultimate schedule for producing a commercial undersea cable is presently unknown, the design and construction of a prototype cable is projected for 1987 when a 30,000 foot length of test cable will be laid in the ocean channel between the Big Island and Maui. (Stanley Tanno's Testimony, Tuesday, December 18, 1984).

15. If a commercial cable is feasible, the demand for geothermal electricity may increase beyond the projected HELCO demand for the Big Island. One of the problems in the implementation of the commercial cable program is the interrelationship between the development of the Big Island's renewable alternate energy resources, especially geothermal, and an undersea cable system. The development of the alternate energy resources on the Big Island should be made in tandem with the development of the undersea cable system. (VCA's Exh. 112, p. 17, KGS 8/27/84; Thomas, Tr. Vol. IV, November 14, 1985, p. 157). It would be financially unfeasible to raise the required financing for an undersea cable system and then actually install the cable without the coordinated development of the renewable alternate energy generated, the electrical production

facilities to provide energy to be transmitted upon completion of construction, and the shakedown testing of the cable. (VCA Exh. 112, p. 2; Thomas, Tr. Vol. IV, November 14, 1985, p. 157). Thus, sufficient geothermal resource subzones should be designated to allow this coordinated development to occur.

D. Geologic Hazard

Geothermal resources in the Puna District exist due to the recent volcanic activity in the region. The volcanic activity in essence serves to continually resupply heat to the system. The volcanic activity responsible for the creation of the resource also creates a certain degree of hazard in the form of earthquakes and the risk of volcanic erruptions. The concurrence of these two factors - high probability of geothermal resource and risks in the nature of volcanic activity are common to young geologic areas where geothermal activities are occurring.

1. Lava Flow.

a. (i) Time and location of eruptions cannot be predicted with any degree of certainty (State Exh. 2, p. 38, DOWALD EXH. 12, p. 82, DOWALD EXH. 6, p. B-54, KGS 8/27/84; Moore Testimony, Vol. VI, December 19, 1984, p. 258).

(ii) The upper East Rift Zone is more subject to lava inundation than is the lower rift zone. (Moore testimony, Vol. VI, December 19, 1984, p. 281; KGS 8/27/84).

b. Characteristics of Hawaiian lava flows:

(i) Flows freely in predictable course dictated by ground slope (DOWALD EXH. 12, p. 1; KGS 8/27/84).

(ii) Lavas are liquid and, therefore, will behave like a liquid. Lavas always tend to flow directly down the steepest available slope and to follow the path of least resistance (Campbell Exh. 6, p. 269; KGS 8/27/84).

(iii) Liquid lava has a specific gravity probability 2 to 2.5 times that of water (Campbell Ex. 6, p. 270; KGS 8/27/84).

(iv) Most flows are thin, 1-5 m. in thickness. Flows will accumulate over previous flows (DOWALD EXH 12, p. 1; KGS 8/27/84).

(v) Duration of flows have averaged 60 days with many lasting 1 day and some such as Mauna Ulu and Pu'u O lasting over a year (DOWALD EXH 12, p. 2; KGS 8/27/84).

(vi) Lava flows are most likely to emanate from vents and fissures located in the central part of the rift zone (i.e., between 90% probability line) (DOWALD EXH. 12, p. 18; KGS 8/27/84).

c. All flows, including current Pu'u O eruption, eventually end (Moore Testimony, Vol. VI, December 19, 1985, p. 2; KGS 8/27/840.

d. The entire Kilauea East Rift is vulnerable to inundation (Helsley Campbell Exh. 1, p. 2; KGS 12/23/84).

e. Mitigation measures are available.

(i) Depending on resource location, siting facilities, including wells away and upslope from central rift zone will mitigate damage to facilities from flows. (Moore Testimony, Vol. VI, December 19, 1985, p. 234; KGS 8/27/84; Niimi Written Testimony, 4/23/84 Hazards Hearing).

(ii) Building diversion barriers to deflect lava flows have an excellent probability of success. (Campbell Exh. 6, p. 258, DOWALD Exh. 12, p. 9; KGS 8/27/84).

(iii) A well placed barrier can deflect lava flows considerably higher than the barrier itself. (Campbell Exh. 6, p. 258, Moore Testimony, Vol. IV, December 19, 1985, p. 269; KGS 8/27/84).

(iv) Division walls can be built quickly and inexpensively. (Moore Testimony, Vol. IV, December 19, 1985, p. 269; KGS 8/27/84).

(v) Geographical diversification of plants and development (Moore Testimony, Vol. VI, December 19, 1984, p. 234, 235, 238; KGS 8/27/84; DOWALD EXH. 12, p. 8; KGS 8/27/84).

(vi) Modular and portable power plants (DOWALD EXH. 12, p. 7; KGS 8/27/84).

(vii) Pipeline supports may be protected against flows with localized barriers or support structures (DOWALD EXH. 12, p. 7; KGS 8/27/84; Niimi Testimony).

(viii) If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from lava flow hazard, wells or plants can be sufficiently fortified to withstand almost any lava flow (Mullineaux and Peterson, 1974). A cost/risk analysis would have to be made. (DOWALD Exh. 12, p. 6; KGS 8/27/84).

(ix) Another well-protection alternative is to enclose the well-head in a concrete cellar allowing the lava to flow above rather than around the well-head. Recovering a well covered with a thick flow could be quite arduous and time consuming. The precise effect the lava's heat would have on the well-head mechanisms is not known. (DOWALD Exh. 12, p. 6; KGS 8/27/84).

(x) Modern metallurgy is quite capable of handling situations where lava is encountered on the surface or subsurface. Wellbore bridge plugs will be available to isolate any productive sub-surface formation if drilling operations must be curtailed. In addition, surface valves and blowout preventers will provide further security. The general practice is to install redundant valves or blowout preventers for reliability. The major supplier of geothermal wellheads and valves is W-K-M. They have stated that the wellheads and valves will not melt even if covered by a lava flow. Experiments by Sandia Laboratories in Kilauea Iki Lava Lake showed that casing can be installed even in molten lava and that heat exchangers exposed to molten lava withstood the temperatures and gases. (Campbell Exh. 1, p. 4; GS No. 9/26/85-5).

(xi) Comprehensive evacuation plans should be designed to assure worker safety. Warning time prior to inundation can be as little as one hour to eruption. (Moore, 1984). Procedures should be established to protect equipment. Multiple access roads should be provided in the event one gets covered by a flow. (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xii) The development should coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory) and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. The developers have been giving this area their attention. (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xiii) If a lava flow is impending during well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing, portion of the well. These plugs can be installed in one hour (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xiv) Trip wires, placed in the expected lava flows, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan (DOWALD Exh. 12, p. 7; KGS 8/27/84).

f. It is generally assumed that the resource developers will bear the risks of loss associated with their activities. However, if the utility owns the power plant, there may be some question as to whether the investors or the rate-payers will bear the risks of loss. Plants could be designed to have large operating ranges to make up lost capacity. (Campbell Exh. 2, p. 5; KGS 8/27/85; DOWALD Exh. 12, p. 8; KGS 8/27/84; Campbell Exh. 1, p. 3).

g. If geothermal development investors assume a major portion of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity. (DOWALD Exh. 12, p. 8; KGS 8/27/84).

h. Well heads and valves will not melt when covered by lava (Campbell Exh. 2, p. 4; KGS 8/27/84).

i. Technology for operating in magma is available from direct research experiments (Campbell Exh. 2, p. 4; KGS 8/27/84).

2. Pyroclastic Fallout

a. Not expected to be an impact in Upper Rift (DOWALD EXH. 14, fig. 8; KGS 8/27/84).

b. Not expected to be problem more than 1 km. away from eruptive vent or fissure (Kubacki Testimony, Vol. IV, p. 324, December 16, 1984; KGS 8/27/84).

c. Cooling towers may be affected but roofs can be designed to mitigate impact (Kubacki Testimony, Vol. IV, p. 324, December 16, 1984; KGS 8/27/84).

d. Not expected to be a problem because of lack of shallow ground water (DOWALD EXH. 12, p. 3; KGS 8/27/84).

3. Ground Cracks

a. Evidence of magma intrusion into the subsurface (DOWALD EXH. 12, p. 3; KGS 8/27/84).

b. Cracks may also be caused by earthquakes (DOWALD EXH. 12, p. 3; KGS 8/27/84).

c. Tectonic ground cracking is usually localized near major fault systems such as in Hilina and Koae (DOWALD EXH. 12, p. 3; KGS 8/27/84).

d. Some cracks may not be positively indentifiable because of forest cover (Jackson, Tr. Vol. VI, December 19, 1984, p. 194; KGS 8/27/84).

e. Based on crack frequency and erruption frequency, there would be greater hazard with Kahauale'a than there would be downrift. (Jackson, Tr. Vol. VI, p. 20, December 19, 1984; KGS 8/27/84).

f. Cracks are oriented primarily vertically (DOWALD EXH. 12, p. 4; KGS 8/27/84).

g. Cracks and fractures are one of the elements you look for when searching for a geothermal resource. (Jackson, Tr. Vol. VI, p. 188; KGS 8/27/84).

h. Measures to mitigate the impact of ground cracks:

(i) Steam transmission piping can be made with expansion joints to accommodate appreciable subsidence and ground movements.

(ii) Siting away from surface cracks. (Jackson, Tr. Vol. VI, p. 189, December 19, 1984; KGS 8/27/84).

i. Depth of surface cracks are unknown. (Jackson, Tr. Vol. VI, p. 190, December 19, 1984; KGS 8/27/84).

j. No impact from cracks was experienced in any of the existing wells despite the fact that at least 2 of the 6 wells were sited close to the surface cracks. (Niimi 1984, Evidence of geothermal potential at Kahauale'a).

k. Impact on well drilling is unknown. A fault could intersect a wellbore without causing any damage. The fault could seal off the well or the faulting could crimp the end of the casing and not allow fluids to escape. (Jackson, Tr. Vol. VI, p. 190, December 19, 1984; KGS 8/27/84).

4. Ground Subsidence

a. Subsidence in rift zones are associated with magma intrusion (McDonald, Volcanoes in the Sea, p. 39).

b. Subsidence may be caused by fault displacement associated with tectonic activity along major fault systems such as Hilina and, therefore, not likely to affect rift zones (DOWALD EXH. 12, p. 4; KGS 8/27/84).

c. Grabens are most likely to occur in the central portion of the east rift (DOWALD EXH. 12, p. 18; KGS 8/27/84).

d. Mitigating Measures:

(i) Siting facilities away from central rift zone (DOWALD EXH. 12, p. 5; KGS 8/27/84).

(ii) Installation of automatic well shut-off devices and pipeline block valves to prevent geothermal fluids from entering any damaged pipeline sections (EIS).

(iii) Geologic surveys to ensure site stability (DOWALD EXH. 12, p. 4; KGS 8/27/84).

5. Earthquakes

a. Most earthquakes in Hawaii are volcanic and result from near surface magma movements. These earthquakes are small in magnitude and usually cause little direct damage. (DOWALD Exh. 12, p. 4; KGS 8/27/84).

b. A November, 1983 earthquake registering 6.6 on the Richter scale did not cause any damage to HGP-A facilities. (Moore Testimony, Vol. VI, December 19, 1984, p. 291; KGS 8/27/84).

6. Tsunamis

a. Hazard is present only to areas below 75 feet elevations (DOWALD EXH. 12, p. 5; KGS 8/27/84).

b. Proposed Kilauea Middle East Rift Subzone is located at elevations generally above 1,400 feet. (State Exh. 2, p. 41).

E. Social Impacts

a. Potential social impacts resulting from the designation of a subzone in Kilauea Middle East Rift Zone would be to health, noise, lifestyle, culture and community setting, and aesthetics.

b. A survey study conducted by SMS Research, Inc., for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, The Puna Community Survey, completed in April, 1982, interviewed 778 residents in the Puna area and among the questions asked was the following:

> Question No. 18 [3]: "Have you or members of your household been affected by those wells in any way? [Geothermal wells in Puna]."
>
> Only 18% of the respondents answered "yes" and 81% of the respondents answered "no", with 1% answering "Don't know."
>
> (DOWALD Exhibit 8, p. 2)

1. Health

a. Of the 18% of households which indicated that they were affected in any way by geothermal wells in Puna, only 14% indicated they were affected by health problems while 71% perceived smell as the negative effect of geothermal wells. (DOWALD Exh. 8, p. 2)

b. In the "Puna Speaks" case, where the HGP-A plant was challenged by Puna residents, the U.S. District Court ruled that the plaintiffs did not prove their case in the suit as no causation was established between the well emissions and the maladies alleged by the plaintiffs which they claimed were caused by the HGP-A plant. (DOWALD Exh. 8, p. 3).

c. A Dames and Moore study for the U.S. Environmental Protection Agency entitled <u>Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii</u>, January, 1984, concluded in part that:

> H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emissions control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities.
>
> Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds. (DOWALD Exh. 8, p. 4)

<u>2. Noise Aspects</u>

a. Noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size. (DOWALD Exh. 8, p. 4).

b. In May of 1981, the County of Hawaii Planning Department issued a set of <u>Geothermal Noise Level Guidelines</u> to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. Because these guidelines answer directly to the noise concerns, they are presented in the following excerpts:

> In granting Special Permits for the exploration and development of geothermal resources in the Puna District, the Planning Department and Commission found that there were potential adverse impacts to the surrounding area which may result from the geothermal operations. Consequently, stringent controls and conditions were attached to the respective permits. The Planning Commission assigned the Planning Director the primary responsibility for the monitoring and enforcing of these conditions.
>
> In light of these responsibilities and the numerous noise related complaints received from residents of the Puna District concerning certain geothermal drilling operations, the Planning Department has developed the following guidelines to determine acceptable noise levels for both geothermal exploration and production.
>
> These noise levels are intended to provide the Planning Director with the necessary guidance to review and assess geothermal operations on a case specific basis to determine whether a noise nuisance exists or not. Based on this review, should the Planning Director find that the acceptable noise levels are being exceeded and that the residents are being significantly adversely impacted by that noise, he can: (1) invoke more stringent noise mitigative procedures and/or mitigative devices; or (2) ease further geothermal activity in accordance with the appropriate provisions of the Special Permits.
>
> Guidelines
>
> In conjunction with the various acceptable noise standards and the factors specifically affecting the Puna environment, the Planning Department has developed the following noise level guidelines for geothermal activities:
>
> 1. That the acceptable geothermal noise guidelines should be at a level which reasonably assures

that the Environmental Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met.

2. That the sound level measurements should take place at the affected residential receptors.

3. That, in conjunction and appreciation of the other guidelines, the acceptable noise levels for geothermal development are as follows:

   a. That a general noise level of 55 dBA during daytime and 45dBA at night not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours of 7:00 p.m. and 7:00 a.m.;

   b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period.

   c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation; and

   d. That sound level measurements be conducted using standard procedures with sounnd level meters using "A" weighting and "slow" meter response unless otherwise stated.

The guidelines for allowable geothermal noise levels are intended to provide an interim basis for assessing geothermal activities. As more information is obtained and a better understanding of both the noise levels and their impacts on the environment and the climatic conditions affecting the Puna area, these guidelines should be amended.

3. Lifestyle, Culture and Community Setting

a. In the survey done by Puna Hui Ohana, Assessment of Geothermal Development Impact on Aboriginal

Hawaiians found that "the question asking about overall: impact of geothermal development in Puna produced responses in the "neither good nor bad" middle ground. There seems to be a balancing of the potential economic benefits of geothermal development with the environmental and social costs of development. (DOWALD Exh. 8, p. 9-10).

b. Pele Practitioners. The Pele practitioners, R.P. Dedman and E. Aluli, have stated that the commercial development of geothermal energy will be an impermissble interference with their native Hawaiian right to practice their religious reverence for the Goddess Pele. (Dedman and Alului, written testimony, Kilauea Middle Rift Geothermal Subzone, November, 1985).

(1) These Pele practitioners believe that the Goddess Pele is embodied in the geothermal resource and that the utilization of that resource is a desecration of Pele. (Dedman, Tr. Vol. V, p. 143, lines 23 and 24).

(2) To many native Hawaiians, Pele is regarded as an akua or an aumakua and personal offering are made to Pele as part of religious practice. (DOWALD, Exh. 2, 3rd Paragraph, p. 13).

(3) Some native Hawaiians also identify themselves as the bloodline of Pele and believe that geothermal development may forever extinguish or destroy

essential parts of Hawaiian heritage, culture and religion. (DOWALD, Exh. 2, 3rd paragraph, p. 13).

(4) The belief that the development of geothermal steam for the generation of electricity is a desecration of Pele is not universally shared by all native Hawaiians. Historical accounts of native Hawaiian activity show that they used geothermal steam for cooking food for non-religious purposes such as feeding animals. (Account of Rev. Ellis; Handy and Handy, DOWALD, Exh. 2, 5th paragraph, p. 13).

(4) Other native Hawaiians currently believe that the development of geothermal energy is not counterproductive to native Hawaiian culture and heritage. One of these native Hawaiians has stated that, ". . . as a Hawaiian who shares the love of this land with others, cognizant of my heritage and traditions, I feel my ancestors would be proud to know that we are trying to use our natural resources in the best way possible. The Hawaiian of times past, with his astute knowledge of all things and through the proper observances of established laws, used all of the natural resources available in their limited way to do the most good for the most people." (Testimony of G. Jenkins, Public Hearing on Middle Rift Geothermal Subzone, September 26, 1985).

(5) Other people speaking on behalf of Hawaiian civic groups have spoken in support of geothermal development. The president of the Hawaiian Civic Club in Ka'u stated in support of the designation of a geothermal resource subzone that, ". . . we are not living in the past now. There's a lot of things we need to preserve, and yet there's a lot of things that sometimes we have to give up for the betterment of our own Hawaiian children and families. Now, we speaking on behalf of myself, talking about geothermal, I cannot say that I know I too much about geothermal. But I think I know enough that I would sit here and support the geothermal resource subzone . . . ." (Testimony of A. Carriaga, Public Hearing of the Kilauea Southwest Rift Zone Geothermal Resource Subzone, September 26, 1985).

4. Aesthetic

a. In some areas with potential geothermal resource development the plant installation may be relatively unobtrusive -- where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors (DOWALD Exh. 8, p. 10).

b. Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures, towers and plants with colors to blend in with the natural setting.

CONCLUSION

c. Overall indications are that the elements of major social concerns and impacts could be minimized and preservation of quality environment could be achieved by proper siting, landscaping and design of plant facilities, and careful controls and monitoring of all operations. The necessity and desirability of furthering the on-going processes of accessing community input from all sectors should be emphasized. (DOWALD Exh. 8, p. viii).

F. Environmental Impacts

1. Meteorology

1.1 Normal Wind Patterns

Normal wind patterns during the day and night blow away from closest receptor areas in Kaohe Homestead and Pahoa the majority of the time. Areas which are downwind of the proposed subzone, specifically the Kalapana area, are approximately 5 miles from the middle of the proposed subzone. (State Exh. 2, pp. 20, 21, 22).

1.2 Air Dispersion Modeling

Air dispersion modeling can be done to calculate specific impacts of a power plant at the CDUA permit acquisition process. (State Exh. 2, p. 20).

2. Flora and Fauna

2.1. Data Derived on Habitat Cuality and Biology

a. For purposes of the subzone designation process, the University of Hawaii Environmental Center developed a simplified, three category impact sensitivity classification system based on vegetation type data from the USFW's mapping. These categories are:

> Category 1 - excêptional native forest; closed canopy, over 90% native cover;
>
> Category 2 - mature native forest, over 75% native canopy; and
>
> Category 2A - native scrub or lava forest.
>
> Category 3 - cleared land; non-native forest; bare ground or lava
>
> Closed canopy is defined as greater than 62% cover, open canopy as 25-60% cover; and scattered trees as 5-25% cover.
>
> (DOWALD Exh. 10, p. 7 and Appendix A, pp. A-1 to A-4).

b. Category 3 lands as defined are presumed to be areas in which geothermal development would have little or no impact and are assumed to be of little biological value owing to high degrees of disturbance or low percentage of ground cover. (VCA Exh. 19, p. 4).

c. At the Kahauale'a subzone hearing, VCA's witness, James Jacobi, testified that the impact of geothermal development would be less significant if the development were to go on in the areas which have been inundated by lava and would have the least impact if the road development were totally confined to recent lava flows. (Jacobi, Tr. Vol. II of IV, December 19, 1984, pp. 22-23).

d. The lava ecosystem in the Kilauea East Rift Zone includes recent, barren flows as well as slightly older flows which support a pioneer vegetation. There have been several studies of plant succession on lava flows on Hawaii (Forbes 1912, Clements 1916, MacCaughey 19717, Robyns and Lamb 1939, Skottsberg 1941), however, the information from these studies is still only fragmentary. A few intensive studies of plant succession have been made at selected sites. Doty (1961, 1967) established several study plots on the 1955 lava flows. Smathers and Mueller-Dombois (1974) conducted intensive studies of succession on ash and pahoehoe at the 1959 Kilauea Iki eruption site.

The results of these studies show how diverse are the successional stages involved and how difficult it is to generalize effectively about succession on lava flows. The great range of environmental conditions available have produced a complex of successional stages.

From these studies it is clear that available moisture plays an important part in succession. Whether a lava flow occurs in a wet or dry locality will determine how rapidly plants are able to colonize it. In wetter areas, the development of vegetation is much more rapid. The whitish-gray lichen, Stereocaulon vulcani, often appears first on some lava flows, however, higher plants such as 'ohi'a (Metrosideros collina) and ferns such as swordfern (Nephrolepis multiflora) may also appear at the same time. "Ohi'a is the most common pioneer among the flowering plants and may even appear before the lichens. In dry localities colonization of lava flows is exceedingly slow.

Lava flows of different ages and climatic exposures can be observed in the Kilauea East Rift Zone. The Pu'u O'o flows (1983 to present) are completely barren for they are too recent and, in fact, newer flows often pour over the earlier flows. (State's Exh. 3, pp. 7 and 8).

2.2 Data on Flora in Proposed Subzone

a. The vegetation (the plant cover) in the proposed subzone was classified into a number of types by Char & Lamoureux in the Puna Geothermal Area Biotic Assessment (State's Exh. 3) and the Botanical Survey of the Potential Geothermal Areas in the State-owned Land in the Middle East Rift Zone of Kilauea, Puna District, Island of Hawaii (Char & Lamoureux, 1985b) (Campbell Exh. 2, pp. 1-2; State's Exh. 3). Based on these studies, the vegetation in the proposed subzone can be classified into the following basic types:

(i) Lava flows.

The most recent lava flows, still largely unvegetated, are those from the 1983-85 Pu'u O'o flows which are still unvegetated. There are also 1977 and 1955 lava flows which support early successional stages with scattered young 'ohi'a plants and a mixture of common native and introduced species.

(ii) 'Ohi'a-uluhe woodland.

This is a forest which probably represents a later successional stage than (i) above. It consists of scattered 'ohi'a trees with an almost continuous carpet of uluhe fern. There are few other native plants such as kopiko and 'uki. Introduced species such as malabar melastome and bamboo orchid are common.

(iii) 'Ohi'a forest types.

These represent still later successional stages. Four such types were recognized:

(1) Wet 'ohi'a forest with native species ('ohi'a-a(1)).

These forests have tall 'ohi'a trees, usually more than 30 feet, with a nearly closed canopy. There is a subcanopy layer containing a number of native trees, and a third layer of hapu'u tree ferns, plus a ground cover of ferns and small shrubs. Very few introduced weeds occur here.

(2) Wet 'ohi'a forest with native species and exotic shrubs ('ohi'a-a(2)).

These forests differ from 'ohi'a-a(1) by containing a large number of introduced species in the shrub and subcanopy layers. Strawberry guava and malabar melastome are the major introduced species. The presence of these introduced plants indicates that these forests are more highly disturbed than 'ohi'a-a(1) forests.

(3) "Ohi'a-kukui forest with mixed native and exotic shrubs ('ohi'a-a(3)).

This differs from 'ohi'a-a(2) by containing an admixture of the kukui, a tree introduced by the Polynesians. Other plants found here, such as 'awa and ti, suggest that these areas were probably utilized by the Hawaiians in former times.

(4) 'Ohi'a forest with exotic subcanopy and shrub layers ('ohi'a-b).

These are 'ohi'a forests which have been greatly disturbed in the past and in which the subcanopy layers consist largely of introduced species.

The 'ohi'a-a(1) forest is the most intact forest type, with the largest component of native species. It is the type which will be most sensitive to disturbance. (Campbell Exh. 2, pp. 2-3).

b. In the proposed geothermal subzone, the different vegetation types occur as a mosaic reflecting lava flows of different ages and different degrees of past disturbance. Extensive areas of 'ohi'a-uluhe woodland, 'ohia-a(2) forest and recent lava flows are interspersed with small patches or 'ohi'a-a(1), 'ohia-a(2), 'ohia-a(3) and 'ohia-b forests. (Campbell Exh. 2, p. 6; Campbell Exh. 2-D).

c. In comparing the state of the vegetation found in the Natural Area Reserve and Kahauale'a, Rick Warshauer stated that the natural area has a large number of introduced plants scattered through it and has a lot of area that is successionally less mature than is the Kahauale'a area. In the latter areas the less mature areas have lots of polluting, and that usually takes the place of a number of native shrubs and herbs that you would find that are abundant in parts of Kahauale'a, particularly areas near the East Rift. (CDUA Hearing Tr. Vol. XIV, p. 3815).

d. Mr. Warshauer also found that Kahauale'a is one or the best native forests left on the Kilauea East Rift and that it is a better example of a native Hawaiian rainforest that the natural area. (CDUA Hearing Tr. Vol. XIV, p. 3815).

e. A prior VCA witness, Dr. Mueller-Dombois, stated at the CDUA hearing that in terms of ecosystems, Kahauale'a is considered to be a prized area in terms of the natural history of the Big Island. In his opinion, the forest at Kahauale'a is in even better condition than the natural area next to it which had been selected by the Hawaiian Natural Area Commission as a prized area to set aside as a national ecosystem. (Mueller-Dombois, Vol. XII, CDUA Hearing, December 8, 1985, pp. 3384-3385).

f. In making a botanical comparison of Kahauale'a with respect to other areas around it, Mr. Jacobi believed that in terms of the value of Kahauale'a it would be in terms of two perspectives:

One, in terms of the ecosystem of that Puna area as a whole, and that is specificaly important in--for example looking at areas of different age substrate. Looking at the evolutionary processes and the development of processes which are going on which are related to many different factors in time. The most important factor is there aren't any other extensive areas which have what are considered in this case a moderate age substrate. This is again referencing the work of Dr. Holcomb who has spent a lot of time talking about different ages of substrate and vegetation development on those types of substrate. What we have in Kahaualea's is a so-called moderate age substrate which we have on the rift zone around the island, but most of those habitats are drier habitats. They're a different vegetation zone, and so we have a different kind of vegetation. And this is the largest expanse we have. This wet, moderate rain forest and the ecosystem processes there are very important in respect to other areas, specifically within the Puna area.

In terms of the value of an intact and still more or less functioning ecosystem, Mr. Jacobi certainly would put a higher value on this area for several reasons. It has been maintained as being a more functioning ecosystem as opposed to, for example, the areas to the east, including parts of most of the Puna Forest Reserve.

The Puna natural areas and some of the areas you get to the drier portion of the Park which are a little bit more disturbed. Mr. Jacobi thus considered Kahauale'a to have an extremely high value and that the upper portion of Kahauale'a has a very high value for the ecosystem. (Jacobi, Tr. CDUA Hearing, Vol. XIV, pp. 3888-3890).

g. Mr. David Ames, the superintendent of the Hawaii Volcanoes National Park, stated during the contested case hearing for the CDUA for Kahauale'a that the National Park is opposed to development at Kahauale'a and would prefer a land exchange with State lands near the Puna Forest. Mr. Ames based this recommendation on the lesser biological value of the area in the Puna Forest. (Ames, Tr. CDUA Hearing, Vol. XIII, p. 3584).

2.3 Data on Endangered, Threatened or Rare Plants

a. There are at least three plant species in the proposed geothermal subzone which have been listed by the U.S. Fish and Wildlife Service in 1980 as either Category 1 or Category 2 candidates for listing as endangered species. Category 1 species are those for which the Service had sufficient information to support the biological appropriateness of listing, but for which data still needed to be collected concerning the enviromental and economic impacts of listing and designation of critical habitats. Category 2 species are those for which the Service had information indicating the probable appropriateness of listing as endangered or threatened, but for which sufficient information was not yet available to biologically support the listing. These three plants are:

(1) Bobea timonioides or 'ahakea which occurs in the proposed subzone, principally in 'ohi'a-a(1) and a(2) forests. It is uncommon except for one population in the northwest portion of the subzone in 'ohi'a-a(1) forest. It is a Category 1 species. Bobea Timonioides has also been sited in the Kapoho GRS, and at two sites along the lower rift zone outside the Kilauea middle east rift proposed

subzone. (Campbell's Exh. 2, pp. 4-5; State's Exh. 2, p. 32).

(2) Cyanea tritomantha or "aku 'aku is also a Category 1 species. It is very rare in the proposed geothermal subzone, where a few small populations were found in 'ohi'a-a(1) and a(2) forests.

(3) Tetraplasandra hawaiiensis or 'ohe is a Category 2 species, which has in recent years been found scattered widely through Puna as scattered individuals or small groups between 100 and 3,100 feet elevations. Its range is more extensive than previously believed and it is not currently considered to have a high priority for listing. (Campbell Exh. 2, pp. 4-5; Dr. Lamoureux, Tr. Vol. VI, November 15, 1985).

(4) A fourth plant, Adenophorus periens, is a Category 1 species. During the U.S. Fish & Wildlife Survey in 1979, one tree with a clump of ferns was found within the proposed subzone, but its principal remaining population is in the 'ohi'a-a(1) forest to the west and north outside of the proposed subzone. It may occur in small numbers in 'ohi'a-a(1) forests in the western part of the subzone but has not been sighted there to date. (Jacobi, Tr. Vol. V, pp. 45-46; Campbell Exh. 2, pp. 5-6; State's Exh. 3, p. 100-103).

b. Whereas, Mr. Jacobi outlined what he believed to be a high biologically sensitive area (Warshauer's Exh. 2), Dr. Lamoreux stated that based on his findings, the most sensitive areas in the proposed subzone are those areas which have been categorized as ohia-a(1). The next most sensitive are at least parts of the forest characterized as ohia-a(2), as those are the two areas within which one is likely to find such things as rare and endangered species. A large part of the area which is representated by the portion shown in white on Warshauer's Exhibit 2 consists of fairly recent lava flows. While these are of importance as far as supporting early stages of succession, in terms of biological sensitivity, as the term would be usually used, that is, the potential danger to rare and native species, these areas are much less sensitive. The most sensitive areas are the a(1) forest and the a(2) forests. (Lamoreux, Vol. VI, November 15, 1985, pp. 101-102).

2.3 Data on Fauna

a. In 1979, the U.S. Fish and Wildlife Service conducted a census of native forest bird species found in the Puna Forest Reserve and the Wao Kele 'O Puna State Natural Area Reserve. The information gathered from this survey was compiled in the Hawaii Forest Bird Recovery Plan which proposed those areas of esential habitat for native forest birds. Figure 2 of VCA Exh. 7 shows the location of the transects used by the Service during its survey in the proposed subzone area. (VCA Exh. 7, Figure 2).

b. Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow (Alala) on the island of Hawaii and for the Nene on both Maui and the Big Island. (DOWALD Exh. 10, p. 6)

c. The Hawaii Forest Bird Recovery Plan is subject to modification as dictated by new findings and changes in species status and the completion of tasks assigned in the Plan. (Jacobi, Vol. I, December 19, 1984, p. 79)

d. The area of essential habitat as defined for the O'u, an endangered native forest bird in the Kilauea Middle East Rift Zone is that area above the 2,000 foot elevation contour which includes a small portion of the northwest corner of the proposed subzone (Conant, Tr. Vol. II, November 13, 1985, p. 45; Jacobi, Tr. Vol. V, November 15, 1985, p. 43).

e. Areas defined as essential habitat for the Big Island include grazing land, logging areas, roads and buildings. (Jacobi, Tr. Vol. I, p. 83).

f. In Dr. Conant's opinion, in terms of forest bird habitat, Kahauale'a is better bird habitat than the forests found in the proposed subzone area. (Conant, Tr. Vol. II, November 13, 1985, p. 77).

g. There are no recorded sightings of the O'u in the proposed subzone area. (Conant, Tr. Vol. II, November 13, 1985, p. 663).

h. VCA's witness, Dr. Conant, testified that there is a lack of information on the biology, ecology and population size on the O'u. Critical habitat for the O'u has still not been established (Tr. Vol. II, p. 127; Tr. Vol. II, November 13, 1985, pp. 69-70).

i. Species of native birds which have been sighted in the proposed subzone are the endangered I'o and the Pueo. (Conant, Tr. Vol. II, November 13, 1985, p. 71; Jacobi, Tr. Vol. V, November 15, 1985, p. 52).

(i) I'o. The distribution of I'o or Hawaiian Hawk is widespread, however, they are found to be a little more abundant in some areas of lower Puna. The I'o is also commonly found on the Kona Cost. It is a wide-ranging bird which has been found in areas of human disturbance which indicates it may not be as sensitive to human disturbance as other endemic Hawaiian birds. Although the I'o is fairly sensitive to disturbance at the nest site, its nest has never been found at Kahauale'a or the Kilauea Middle East Rift Zone. (Conant, Tr. Vol. II, November 13, 1985, p. 71; Jacobi, Tr. Vol. V, November 15, 1985, p. 52; BLNR's DNO, Feb. 25, 1983, p. 4-37).

(ii) *Pueo*. The Pueo is a permanent resident on all main islands of the Hawaiian Chain. The birds occur from sea level to at least 8,000 feet on Mauna Loa and Mauna Kea, and the birds are tolerant of wide climatic conditions. The Pueo differs from most other owls in that it is diurnal in habit; hence, they are seen much more often than the nocturnal introduced Barn Owl (*Tyto alba*). While the Pueo is considered endangered on the Island of Oahu, it is not classified as endangered for the Island of Hawaii. (State's Exh. 3, p. 74; Conant, Tr. Vol. II, November 13, 1985, p. 71).

j. Although VCA witness Jacobi stated that another species of bird, the A'o, or Newell's Shearwater, which is classified as a threatened species, may also use the State Forest Reserve lands, the only evidence found of breeding near the proposed subzone parcel is at Makaopuhi Crater where an adult A'o and an egg was found in 1972. The only large known nesting grounds for the Shearwater are on Kauai.

k. VCA's witness, Mr. Jacobi, further stated that there were probable nesting colonies of A'o in the vicinity of the proposed subzone, but his only evidence was the reference to the nest found at Makaopuhi Crater in 1972 and the fact that a similar type of habitat in which A'o are expected to be found on the Big Island (i.e. the flanks of Mauna Kea) is also found in the Puna area. (VCA Exh. 7, Tr.

Vol. V, pp. 37-41; VCA Exh. 44, p. 9; Exh. 46; Tr. Vol. II, pp. 147-148). No live colony of A'o have ever been found in the area of the proposed subzone. (Jacobi, Tr. Vol. II, p. 148).

l. VCA witness, Dr. Kenneth Kaneshiro, an entomologist, stated that in the present major Hawaiian islands from Kauai to the Big Island, slightly more than 500 species of an endemic fly, Hawaiian Drosophila, have been collected and described. In the University of Hawaii's collection are contained another 100 to 300 species of this fly which are new and yet undescribed species. (Kaneshiro, Vol. II, November 13, 1985, pp. 15-16).

m. While Dr. Kaneshiro thought that there may be unique species of Drosophila to be found in the middle east rift zone area, unique species of Drosophila have been found throughout the State of Hawaii. (Kaneshiro, Vol. II, November 13, 1985, p. 30).

n. In Dr. Kaneshiro's opinion, the genetic processes of evolution in terms of the Drosophila are not more dynamic in the rainforest habitat than in dry land habitats. However, the older the lava flow or the separation or the longer the separation of the species from each other, the more likely will be the chances of finding genetic differences, which is why Dr. Kaneshiro and his colleagues have studied the kipukas along the Saddle Road where the lava flows occurred about 100 years ago so that there's been a lot more time for differentiation to occur. (Kaneshiro, Vol. II, November 13, 1985, pp. 35-36, 40-41).

o. Although Dr. Kaneshiro's position was that as much of the Wao Kele 'O Puna area as possible should be kept intact for future scientific research, Dr. Kaneshiro admitted that to date no such research has been conducted in that area due to a lack of funds and that he did not have such funds now to conduct any research there. Dr. Kaneshiro also thought that the subzone designation itself would allow geothermal exploration on the property and he wasn't sure if scientists would be allowed to do any further work in Wao Kele 'O Puna if it were designated as a geothermal resource subzone. (Kaneshiro, Vol. II, November 13, 1985, pp. 30-31).

2.4 Impacts to Flora & Fauna

a. Geothermal development will include certain activities that create openings in the forest. These openings may result in alterations in the light, temperature, and the humidity regimes at the edges of the openings, leading to changes in the vegetation. The extent and nature of this edge effect may vary with sizes of the areas cleared. (BLNR's DNO, February 25, 1983, p. 4-35).

b. Based on recent observations of old lava flows through the Kahauale'a parcel, Dr. Lamoureux, estimates that "the edge effect would not be more than 50 to perhaps 100 feet in certain areas. Therefore, the effects of land clearing are not likely to extend much beyond the edge of the cleared areas." (BLNR's DNO, February 25, 1983, p. 5-7).

c. In contrast with the Geothermal Subzone in Kahauale'a, in which the forest is primarily the sensitive 'ohi'a-a(1) type, the proposed subzone affords an opportunity to undertake geothermal development with much less risk to rare plant species. There is the opportunity to locate roads, drill sites, and power plants in less sensitive areas and to avoid, in most cases, the more sensitive small patches of 'ohi'a-a(1) forest. (Campbell Exh. 2, p. 6).

d. Development in 'ohi'a-a(2) forests can be minimized by siting most development on recent lava and 'ohi'a-uluhe areas. Much more flexibility is available in the proposed subzone because the mosaic nature of the vegetation allows a developer to site projects such that the most sensitive vegetation types and species are avoided as far as possible. (Campbell Exh. 2, p. 6).

e. In Dr. Lamoreux's opinion, development could go on in the area outlined in Warshauer's Exhibit 2, as long as the most highly sensitive portions of that area were avoided without any signficant impact on long-term succession. (Lamoreux, Vol. VI, November 15, 1985, p. 102).

3. Surface Waters

a. Geothermal development activities should not directly affect existing land uses since there are no known surface streams in the recommended area. (DOWALD Exh. 10,p. 12; BLNR Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

b. Following initial development of the geothermal resources, the production of potentially valuable associated geothermal products, demineralized water and mineral salts could have beneficial environmental consequences. (DOWALD Exh. 10, p. 12).

c. The normal disposal practice of geothermal fluids is expected to be reinjection, thus avoiding any adverse affects on surface water. (DOWALD Exh. 10, p. 12).

d. Discharge of geothermal fluids upon the land surface during limited well testing operations will not produce a detectable effect on groundwater resources in the Puna District due to the high recharge rate by meteoric water in the area estimated at 4.2 million gallons per day per square mile and the natural emissions of thermal fluids from the rift zone estimated to be 1.4 million gallons a day into the basal aquifer. Current experience at HGP-A indicates that surface disposal of 150,000 gallons per day of geothermal fluids over a period of one years has had a lesser impact on nearby groundwater quality than normal rainfall variations. (BLNR Decision and Order; Baseline Finding 4.1.3, CDUA No. HA 3/2/82-1463).

4. Groundwater Hydrology

a. The hydrology of the Puna District is not well established. The general hypothesis, as in other parts of the Hawaiian islands, is that the area is an underground lens of basal fresh water floating on salt water, with a relatively narrow band of dike - confined water (not floating on salt water) running across the southern part of the District, and with a coastal zone of brackish basal water west of Kalapana. Underlying the rift zone area, the groundwater would be brackish and warm or hot.

b. The groundwater resources of the Puna Distict occur in both confined and unconfined aquifers. The general theory is that the freshwater lens floats on salt water. This is based on the Ghyben-herzbeg concept which states that the lower density fresh water rests on the higher density salt water. The rule is that for each foot of fresh water above sea level, the fresh water extends 40 feet below. An allowance must be made for a mixing or transition zone.

c. It appears that, in the Kilauea East Rift Zone, the hydrology is somewhat unique. The geothermal reservoir's thermal and permeability properties allow fluids to rise near the surface and to be mixed very rapidly through the geothermal system. In addition, as the result of vertical diking and fracturing that run east and west, there is high permeability in vertical and east-west directions; this causes damming or redirection of groundwater flow. A high head of water exists north of the rift zone, whereas to the south of the rift zone, the ground waters are at or near sea level. (BLNR Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

5. Air Quality

5.1 Air Sampling Methods

a. There are several different air sampling methods: The emission rate is defined as what is emitted from a geothermal power plant measured at the point of discharge in terms such as pounds, grams, or kilograms over a unit period of time. The ambient concentration of a particular material is the amount per volume in the air in the environment outside the geothermal plant. The ambient air is what is breathed in the environment and the ambient concentration is the amount of a particular material in the air being breathed.

b. Baseline assessments have been made and air sampling has been one of the measurements taken over an area extending from Royal Gardens Subdivision, which is above the coastal Kalapana Road in the southeast, to Captain's Drive roadway in the Fern Forest Estate Sudivision in the northeast, to the Volcano Road (Route 11) at the access roadway across the Shipman property in the northwest, to Thurston Lava Tube in the northwest, and then south of the Volcano Road across Kahaualeʻa to the lava fields and the Hawaii Volcanoes National Park boundary.

c. BORON: No substantial amounts of boron appear in the ambient air. In the case of geothermal development, boron would not be released to the air, but would stay in the liquid phase at the separator and be returned to the steam field and would not go in through the turbine where it could be released into the atmosphere. Boron would be reinjected and under proper precautions, would not escape during the reinjection.

d. MERCURY: Whether mercury poses a toxic hazard or not must be considered in relation to the natural background levels. It appears that normal background air levels are high, often being of the order of 0.1 to 1 microgram per cubic meter, whereas soil levels can be in the range of 30 to 90 ppb (parts per billion) and rain water 0.1 to 0.3 micrograms per liter. The levels of less than 0.1 microgram per liter in brines are in fact local background levels. Mercury is not expected to be found in any detectable amounts from the cooling towers.

e. RADON: Radon is the result of the decay of radioactive materials that were formed when the earth was formed. In the decay chaining of radioactive materials, radon is formed as a gas. Radon exists in the reservoir at the Geysers and when the steam comes out of the reservoir, it sweeps the radon along into the power plant conversion and abatement system. Radon follows the noncondensable gases through the hydrogen sulfide abatement system and is then vented through the cooling tower and is mixed with a much larger volume of atmosphere. The mixing of the small volume of radon with a large volume of air that goes through the cooling tower does not accumulate in the environment but maintains a constant level as an equilibrium in which the concentration stabilizes. Equilibrium means a state of constant quantity where the amount of formulation and the amount of decay or destruction of the radon are equal so that a constant amount is maintained at any one time.

f. HYDROGEN SULFIDE: Hydrogen sulfide is a poison at acute levels. Chronic exposure to low levels of hydrogen sulfide has never been proven to have any demonstrable effects in humans or animals. Most often effects associated with low levels of hydrogen sulfide are those due to smelling a bad odor and although these effects are unpleasant, they do not appear to constitute a true health hazard.

(i) The ambient EPA health effects level goal is .207 ppm (parts per million). At 0.33 ppm level of hydrogen sulfide, it will have a distinct odor, and may cause headaches and nausea in sensitive persons.

(ii) The OSHA Standard is 20 ppm for a 5-minute period.

(iii) The EPA has recommended as a guideline for geothermal systems, a maximum hydrogen sulfide emission level of 200 grams per megawatt hours (grams/MWH). However, there is no EPA recommended level for ambient air concentrations of hydrogen sulfide.

(iv) There are no adopted standards in Hawaii for geothermal emission rate and ambient air concentrations for hydrogen sulfide.

(v) The "California Standard" for geothermal operations is 0.03 ppm (1 hour average) at the nearest residential property for ambient concentrations and emissions per production unit to not exceed a maximum rate of 200 grams/MWH, with a requirement that compliance be reattained within 24 hours of notification that the standard had been exceeded.

(vi) Campbell has committed to a standard of hydrogen sulfide emissions not to exceed 200 grams per hour per gross megawatt of electricity produced (200 gm/MWe/hr) and a regional air quality standard concentration to not exceed 0.03 ppm (1 hour average) above regional background at the nearest residence with a requirement that compliance be reattained in 36 hours after notification that the standard has been exceeded. Campbell has also proposed that hydrogen sulfide emission from drilling and testing operations shall not exceed 2.5 kg/hr/well.

(vii) The 0.03 ppm ambient standard for hydrogen sulfide represents a safe and prudent safeguard against public health hazards for purposes of the activities permitted at this time.

(viii) The technology for abatement of hydrogen sulfide emissions from the proposed facilities to acceptable levels is available and the flash-steam cycle appears to be the best plan for the expected resource. The geothermal resource can be abated with present technology to meet the California Standards.

(ix) Hydrogen sulfide abatement technology such as the Stretford and burner-scrubber system will lessen the impact on the human and natural environment more than conventional electrical energy production currently in operation today in Hawaii.

g. Sulfur Dioxide: Kilauea Volcano normally emits 200 tons a day of sulfur dioxide and the contribution of sulfur dixoide from the proposed Kahauale'a project at full development would only be a fraction of 1 percent of that amount.

(i) Acid rain is not only the result of hydrogen sulfide or sulfur dioxide emissions. Other emissions such as nitrogen oxides, and halide acids are also necessary. In comparing the biomass and the oil-fired plants, their emission rates in terms of grams per hour are far higher for sulfur oxides and nitrogen oxides at biomass and oil-fired plants under current new source performance standards than for geothermal emissions. (BLNR Decision And Order: Baseline Finding 4.4.1.1, CDUA No. HA 3/2/82-1463.)

5.2 Geothermal Gas or Steam Emissions Data

a. Determinations of the exact nature of the geothermal gas or steam emissions expected to be released into the atmosphere is a product of (1) the current ambient air levels, (2) the effect of various monitoring and abatement programs, (3) the size and nature of geothermal production operations, and (4) the relative presence or absence of volcanic emissions occurring naturally in the project area.

b. Present ambient levels have not been well established. Nonetheless, mercury (a general body poison in sufficiently high doses) and arsenic (a known carcinogen) are understood to be present in the ambient air. The baseline data shows the entire surveyed area to have high ambient levels of air mercury by Environmental Protection Agency standards, although not by National Institute of Occupational Safety and Health standards. Among a variety of chemicals emitted from the geothermal wells, the following chemicals will be present in the ambient air: mercury, arsenic, selenium, hydrogen sulfide, hydrogen selenite, and sulfur dixoide.

d. How effective the various monitoring and abatement programs will be is a function of the size and nature of the geothermal operations, the composition of the geothermal fluids, the state of the technology, and many related factors.

e. The gas or steam phase from a geothermal well will contain carbon dioxide, hydrogen sulfide, nitrogen, hydrogen and traces of several other gases including radon. Of these, concern has been expressed about the hydrogen sulfide and radon. RADON: The amount of radon in the reservoir fluid from HGP-A is 1.82 nanocuries per kilogram of steam, or 1,820 picocuries per liter.

f. HYDROGEN SULFIDE-STANDARDS: Currently, the State's Department of Health Ambient Air Quality Regulations do not set standards for hydrogen sulfide and mercury. California's ambient standard for hydrogen sulfide has been suggested by Campbell as an interim standard. There was testimony that most states and countries around the world have stricter standards for hydrogen sulfide compared with California's or Campbell's proposed standard of .03 ppm. The Air Quality Advisory Commission's report to the Department of Health suggests an ambient air quality standard for hydrogen sulfide of .1 ppm, one hour average. It also recommends that no degradation of existing air quality exceed .025 ppm above current baseline levels. (BLNR Decision And Order: Baseline Finding 4.4.2.1 CDUA No. HA 3/2/82-1463.)

5.3 Consequences of Air and Toxicology Data and Methods

a. The emissions of sulfur, mercury, and other volcanic gases are a continuous process at Kilauea, the rift zone, and the adjacent forest and its inhabitants have long been exposed to lower levels of these potentially toxic emissions and intermittently to higher levels. Exposure to significant levels of geothermal gases are part of the norm for native Hawaiian plants and animals.

b. The most important factors relevant to potential impacts arising from the production of geothermal fluids include the volumes of geothermal fluids being produced; the existing and projected ambient levels of the components to be released; the dose/response characteristics of potential receptors of the emissions, the duration of exposure to the toxicants; and natural emission or loading rates of the individual components.

c. A report recently prepared for the U.S. Environmental Protection Agency, Evaluation of Bact for and Air Cuality Impact of Potential Geothermal Development in Hawaii, analyzes most available H_2S abatement systems. These include iron catalyst primary system; the iron catalyst secondary system; the hydrogen peroxide, caustic, iron catalyst (HPCC) primary system; burner-scrubber system; and the Stretford system. The report recommends the Stretford system as the primary on-line abatement system. This system can remove over 99% of the H_2S contained in the noncondensable gases. By-products of the Stretford system include marketable elemental sulfur and sludge which requires disposal.

d. A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement sytems can be utilized in the event the plant is "down" for maintenance or emergency. If maintenance is required on either the turbine or generator, the geothermal steam can be routed directly into the condenser utilizing the primary abatement systems. Since the turbine does not dissipate any heat or energy in the bypass mode, the cooling system must be over-designed to accomodate the extra heat during "turbine bypass." If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal. In emergencies, well throttling may be accomplished by manual valve turndown or automatic valve control. Throttling must be slow (at least 15 minutes) and can reduce the flow to a fraction of the well's maximum flow rate. The degree of throttling possible will depend upon the characteristics of each well. However, there is a danger that the additional stress with increased pressure could damage the well-bore, casing, or well-head equipment. If a geothermal development has more than one power plant, the wells could be moderately throttled and diverted to an operating plant. If all the above continency abatement options are not available, a geothermal well may have to be free vented through a silencer without H_2S abatement until the required maintenance is completed or such time as the well can be shut-in completely.

e. The abated gases, condensate, and warm water are circulated through the cooling tower. Cooled water from the cooling tower is recirculated through the condenser; any excess water (blowdown) is piped into an injection well. It is expected that a wet, mechanical draft, cooling tower will be applied to geothermal development. Warm water enters the tower near the top, while a fan forces air through slats designed to maximize the surface area of the falling warm water. Use of drift eliminators significantly reduces the chance that any water droplets will exit with the steam plume. This falling water also scrubs any particulates from the gas exiting the abatement system. At "The Geysers" geothermal development in California, small amounts of boron from the condensate has been emitted with cooling tower drift (small water droplets entrained in the steam plume) having some advese effects on nearby vegetation. Based on the characteristics of the HGP-A reservoir fluids and the emissions from Hawaii's geothermal resources should not be toxic to flora and fauna in the vicinity of the geothermal power plant. Data available from the HGP-A indicates the plume from the cooling tower should consist entirely of water vapor. The proposed DOH regulations require 98% H_2S abatement and a concentration of no greater than 25 parts per billion H_2s at the property line of a development.

f. In addition to cooling tower blowdown, brine leaving the separator will be piped into the injection well. If the rate of silica deposition in the brine is high, a silica-dropout system will be utilized between the steam-brine separator and the injection well. Otherwise, silica deposition within the injection well might cause it to become plugged. The silica deposits will be removed periodically and disposed of in an acceptable manner (DOWALD Exh. 11, pp. 4-6).

6. Historic and Archeological Values

a. There are no known archaeological sites within the Kilauea Middle East Rift Zone. (DOWALD Exh. 1, p. 36; DOWALD Exh. 10, Appendix D).

b. If any sites are discovered, damage can be minmized by adjusting the location of geothermal facilities, roads and pipeline alignments. (DOWALD Exh. 1, p. 36)

7. Scenic and Aesthetic Value

a. In some areas, with potential geothermal resource development the plant installation may be relatively unobtrusive -- where scenic view corridors are not damaged in the eye of nearby or medium distanced residents and visitors. (DOWALD Exh. 8, p. 10)

b. Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures, towers and plants with colors to blend in with the natural setting (DOWALD Exh. 8, p. 10).

G. Compatibility with Present and Planned Use

a. The proposed geothermal resource subzone in the Kilauea Middle East Rift Zone consists of approximately 11,745 acres of land and is located in and adjacent to the Wao Kele 'O Puna Natural Area Reserve and Puna Forest Reserve.

b. The great majority of the land within the proposed Kilauea middle east rift GRS is zoned Conservation Protective. The extreme western and southwestern areas of this proposed GRS is zoned agriculture. (State Exh. 2, p. 42).

c. The objective of the "P" Conservation district is to protect valuable resources in such designated areas as restricted watersheds, marine, plant and wildlife sanctuaries, significant, historic, archaeological, geological and vulcanological features and sites and other designated unique areas. (DLNR Regulation No. 4, Title 13, Chapter 2, 13-2-11).

d. Agricultural districts include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities, including but not limited to, living quarters or dwellings, mills, storage facilities, processing facilities, maintenance facilities, and roadside stands for the sale of products grown on the premises; agricultural parks and open area recreational facilities; public, private and quasi-public utility lines and roadways, transformer stations, communications equipment buildings, solid waste transfer stations, major water storage tanks; and wind energy facilities where they are compatible with agricultural uses and cause minimal adverse impact. (Section 205-4.5, HRS)

e. Conservation districts include lands necessary for protecting watersheds and water sources; lands susceptible to floods, soil erosion, inundation by tsunamis and volcanic activity and landslides; lands used for parklands beaches and the preservation of scenic, historic or archaeological sites; lands below the zone of wave
2
action; lands with a general slope of 20% or more; lands with topography, soils, or climate not presently needed or normally adaptable for urban, agricultural or rural uses; and lands suitable for farming, nurseries, flower gardening, growing of commercial timber, grazing, hunting and recreation. (State Land Use District Regulations, Part II, Section 2-2(3)).

f. The proposed subzone is located within a volcanic rift zone marked by ohia forests and lavaflows (DOWALD Exh. 4).

g. The areas to the west of the proposed subzone are already designated as geothermal resource subzones. (State Exh. 2, p. 5).

h. There is a 2,000 foot setback on the western edge of the proposed subzone from the proposed Kahauale'a Natural Area Reserve.

i. The National Park Service did not express an objection to the adequacy of the 2,000-foot setback established by the DOWALD between the proposed Kahauale'a subzone and the Hawaii Volcanoes National Park. In fact, Howard H. Chapman, Regional Director, Western Region of the National Park Service had expressed in writing his appreciation of the extension of the buffer area from 1,000 to 2,000 feet (VCA Exhibit 34; KGS 8/24/84).

j. The 2,000 foot buffer area between the proposed Kahauale'a Natural Area Reserve and the proposed subzone will allow the potential impacts from noise and air emissions from any geothermal activity to be mitigated by the use of the best available technology and the distance between the two areas.

k. The development of geothermal resources in the Kilauea Middle East Rift Zone is consistent with the Hawaii State Planning Act which has an objective and policy of increasing energy self-sufficiency and promoting of the use of new energy resources; and has a priority action of encouraging the development of alternate energy sources (Sections 226-18(a)(2), 103(i)(1), HRS). The development of geothermal energy in the proposed subzone will provide the private sector with opportunities to develop latent geothermal energy resources in those areas where the potential for finding such resources is high. State and

County goals for the development of Hawaii's natural energy resources will, thus, be enhanced and furthered.

1. The development of geothermal energy in the Kilauea Middle East Rift Zone is consistent with the goals and policies of the Hawaii County Plan which encourages the development of alternate energy resources; promotes a proper balance between the development of alternate energy resources and the preservation of environmental fitness; and encourages the use of new energy sources (County Exh. 1, p. 3).

G.1 Compatibility With the Goals and Objectives of the Conservation District

a. The proposed subzone is in the State Land Use Conservation District and in the Protected subzone classification. The objective of the Protected classification is to protect valuable resources in designated areas. (DLNR Regulation No. 4, Title 13, Chapter 2, Section 13-2-11).

b. Section 205-5.1(a), HRS, permits geothermal resource subzones to be established within State Land Use Conservation Districts. Act 155, Session Laws of Hawaii, 1984, specifically states that geothermal development activities may be permitted within conservation land use districts. Both Sections 205-5.1, HRS and Act 155 do not exclude the designation of a geothermal subzone or geothermal development activities within a Protected subzone of any conservation district.

c. The use of an area for the exploration, development and production of electrical energy from geothermal resources within a geothermal resource subzone shall be governed by the Board of Land and Natural Resources within the conservation district (Section 205-5.1(c), HRS).

d. The proposed subzone is located in the Wao Kele 'O Puna Natural Area Reserve which is in and adjacent to the Kilauea East Rift Zone, which is an active volcanic rift zone.

e. The objectives and goals of the Protective subzone do not expressly prohibit geothermal development activities. Conditional uses as defined in Title 13, Chapter 2, Section 13-2-1 (definitions) are allowable within the Protective subzone.

f. Section 183-41, HRS, states that the BLNR should allow and encourage the highest economic use of conservation lands.

g. The nature of geothermal development activities are non-labor intensive activities and are more appropriately characterized as capital intensive. (EIS, CDUA Hearing, Appendix H, H-1; DOWALD Exh., pp. 2 and 3). Therefore, geothermal development activities can be allowed within the Protective subzone by reducing the exposure of humans to the potential volcanic dangers by the strategic placement of powerplants, the erection of berms and platforms to minimize the potential volcanic hazard, the use of escape roads the careful formulation of evacuation plans in advance of potential dangers and the close coordination of the operations of the geothermal project with the Hawaii Volcanoes Observatory to facilitate the exchange of important information (Written Testimony of Gerald Niimi and Louis Capuano, BLNR Hearing, April 11, 1984).

h. The availability of proven geothermal technology such as hydrogen sulfide abatement systems which are capable of abating hydrogen sulfide emissions to 99%; noise reduction technology for well-venting (in-place and portable rock mufflers and drilling emission abatement systems; drilling rig noise reduction techniques (acoustical baffling, hospital muffers, noise reduction enclosures); strategic placement of powerplants and use of landscaping to reduce potential visual impacts; the use of reinjection programs to return geothermal fluid back to the production zone; geothermal well storm plugs and buried cellars; raised platforms and berms; will reduce the potential impacts of geothermal development within the conservation district and and within areas surrounding the proposed subzone. (DOWALD

Exh. 9, Written Testimony of Gerald Niimi, Louis Capuano, BLNR hearing, April 11, 1983).

H. Economic Impacts

1. Probable Community Benefits of the Project

a. In assessing the potential economic impacts of geothermal development on a state-wide and county-wide basis, a 20 to 30 MW scenario was assumed for purposes of the geothermal subzone designation process. (DOWALD Exh. 9, p. vii; Yee Tr. Vol. I, November 13, 1985, p. 122).

b. The State of Hawaii depends on petroleum supplies for 91.4 percent of all the energy consumed in the State. The oil that Hawaii imports costs the State about $1.5 billion per year in funds which flow out of the State for this purchase. As a consequence of the high cost of imported fuel, electricity rates in Hawaii are among the highest in the nation. The Department of Planning and Economic Development believes that geothermal energy is the largest, near-term baseload electric energy potential for Hawaii. Large scale development of the geothermal resources on the Big Island is essential to attainment of the State and County of Hawaii objectives of energy self-sufficiency. (BLNR Decision And Order: BASELINE FINDINGS 4.9.2.2., CDUA No. HA 3/2/82-1463)

c. The revenue generated by the sale of electricity to its customers will increase the gross product of the County, as well as the State. If the assumed 25MW plant yielded approximately 500 megawatt-hours (MWh) per day of electricity at an average rate of $0.054 per kilowatt-hour (KWh), the additional direct revenue would be approximately $27,000 per day or $9.9 million annually. This initial or direct output should stimulate other sectors within the local economy and within the State. These other sectors will increase their output of goods and services as a result. Based on the Department of Planning and Economic Development's multipliers for the State, a $1.00 increase in revenue can potentially increase the total output, i.e., direct-plus-indirect-plus-induced, to approximately $1.70. Therefore, the $9.9 million in direct annual revenue output could provide a long-run total of annual output to the State of approximately $16.8 million. (DOWALD Exh. 9, p. 2).

d. A 1982 study done for the Department of Planning and Economic Development (DPED) indicates that total wage earnings for a 25 MW plant will be approximately $560,000 per year. Based on the 1977 DPED multipliers, the total impact will be approximately $1.3 million in annual incomes to households throughout the State when the full impact of the subsequent rounds of economic activity takes place.

According to the same 1982 study, a 25 MW geothermal plant will require approximately 25 employees to operate it. As a result of this direct employment, an estimated 57 additional jobs will be created after all the repercussions have taken place, both County-wide, as well as within the State. (DOWALD Exh. 9, pp. 2-3).

2. HELCO and the Development of Geothermal Resources

a. About 60 percent of the total energy produced on the Big Island is generated from fossil fuels such as industrial and diesel oils. Due to the uncertainties of the price and supply of fuel oil, HELCO is seeking to ultimately meet electrical system demands solely from renewable energy sources such as geothermal. In order to encourage the development of geothermal resources in Puna by private developers, HELCO issued a Request For Proposal (RFP) regarding the development of the resource for electric generation.

b. Furthermore, HELCO's Forecast Planning Committee is presently looking at a 2 percent per year load growth for the Big Island over the next 20 years. Excess electrical energy produced by geothermal energy could be exported to Oahu and the other islands if the deep-water cable that is currently under study can be installed to electrically connect the islands. (BLNR Decision And Order: BASELINE FINDING 4.9.2.3., CDUA No. HA 3/2/82-1463)

3. Socio-Economic Characteristics of the Big Island's Puna Area.

a. The greater Hilo area and surrounding communities, including Puna, support a current population of approximately 50,000 people with an employment base of 20,000 people.

b. In April 1980, 11,775 persons were living in Puna which constituted roughly 13 percent of the Big Island's population. In district size in population, Puna ranks third after South Hilo and North Kona. Puna's population density of 23 persons per square mile is the same for the County of Hawaii as a whole. Within the Puna District, roughly 20 percent (2,246) of the residents were living in the towns of Keeau, Mountain View and Pahoa.

c. From 1960 to 1980, Puna's population growth rate more than doubled to a 234 percent increase. A disproportionately large part of the population growth in Puna occurred in the age bracket where people are most likely to be in the labor market from ages 22 through 44. As a result, the labor force on the Big Island has been growing faster than work opportunities there.

d. Economic activity on the Island of Hawaii in 1981, was the lowest in the decade of relatively steady growth. Total personal income on the Big Island is the lowest for the four counties in the State. The major industries affected by low earning levels on the Big Island were tourism, sugar and construction. The construction industry has seen its lowest activity in many years in 1981, and in 1982, the effect of the recession, tight money supply and high interest rates have resulted in minimal construction activity.

e. One-fourth of the residents of Puna mention experiencing problems at the present time with services and facilities like road, water and police. (BLNR Decision And Order: BASELINE FINDING 4.9.2.4. CDUA No. HA 3/2/82-1463)

4. Potential Job Creation from the Development of Geothermal Resources

a. In 1979, the total civilian labor force for the Big Island was 35,200 of which 2,900 or 8.1. percent were unemployed. In February 1982, Oahu unemployment was 5.2. percent as compared to 7.8 percent on the Big Island and the forecast is higher unemployment.

b. One important factor in the community's approval of geothermal development is the hope that the direct application of geothermal water will create more jobs. Puna Hui 'Ohana, a community organization which represents four native Hawaiian groups in the Puna area, in general has expressed an attitude in favor of developing the geothermal resource in Puna, but not at the expense of the community environment. Of particular concern to young adult Hawaiians were jobs from which they could make a living and feed their families.

c. The overall assessment for a geothermal power plant up to 50 MW in power will have some impact on a Statewide and County-wide basis, but the impact would probably not be significant (DOWALD Exh.9, p. 12).

I. Compatibility of Geothermal Development in a Conservation District

1. Permissible Use in Conservation District Land Use Commission Conservation Classification

a. Hawaii's land use law (HRS Chapter 205) classifies Hawaii's land into one of four categories: urban, agriculture, rural, and conservation, after which different agencies administer land uses. HRS 205-2 provides that:

> Conservation districts shall include areas necessary for protecting watersheds and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach reserves; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openess,

natural condition, or present state of use, if retained, would enhance the present potential value of abutting or surrounding communities, or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational purposes; other related activities; and other permitted uses not detrimental to a multiple use conservation concept. (HRS 205-2)

b. Like federal land use law (40 USC 1411-18; 43 USC 315; 315, 869; 30 USC 181 et. seq. 30 USC 351-359. Regulations: 30 CFR-whole; 43 CFR subpart 2420; 43 CFR-whole), the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation lands involve multiple uses which range from absolute preservation to resgulated uses. For example, the ocean includes a range of activities from estuaries to harbors. The range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restricted context. With more than one-third of the state in the conservation district, the Board of Land and Natural Resources has developed subclassifications of conservation land to allow for a spectrum of uses to be allowed consistent with the overall purposes of the state's land use scheme. In the instant case, the determination of baseline information and the monitoring, observing, and measuring of natural resources are clearly within the intent and purposes of conservation district.

c. HRS 205-5 further provides that conservation districts shall be governed by the Board of Land and Natural Resources pursuant to Section 183-41. (BLNR CONCLUSIONS OF LAW 8.11.1. CDUA No. HA 3/2/82-1463).

2. Forest and Water Reserve Zones

a. HRS 183-41(c) provides in relevant part that:

(1) . . . The department may establish subzones within the forest and water reserve zones, which subzones shall be restricted to certain uses. In establishing permitted uses in the subzones, the department shall give full consideration to all available data as to soil classification and physical use capabilities of the land so as to allow and encourgage the highest economic use thereof consonant with requirements for the conservation and maintenance of the purity of the water supplies arising in or running or percolating through the land.

The department shall also give full consideration to the preservation of open spaces or areas, as defined in section 201-21(7), so as to maintain, improve, protect, limit the future use of, or otherwise conserve open spaces and areas for public use and enjoyment. Provided, the board shall hold a public hearing in every case involving the proposed use of land in a conservation zone for commercial purposes, at which hearing interested persons shall be afforded a reasonable opportunity to be heard . . .

(2) Review of zones established by this part. The department, . . . shall undertake to review the boundaries of all forest and water reserve zones within each county with the view of making necessary corrections and establishing subzones within the zones, and fixing permissible uses therein. The department shall, after review, prepare a proposed set of regulations, complete with necessary maps, establishing zone and subzone boundaries,

and designating permitted uses therein . . . When adopted and after promulgated as required by law, the regulation shall have the force and effect of law.

(3) Scope of zoning regulations. The department shall, after notice and hearing as provided herein, adopt such regulations governing the use of the land within the boundaries of the forest and water reserve zones as will not be detrimental to the conservation of necesary forest growth and the conservation and development of water resources adequate for present and future needs and the conservation and preservation of open space areas for public use and enjoyment.

The department by means of regulations may establish subzones within any forest and water reserve zone and specify the land uses permitted therein which may include, but are not limited to, farming, flower, gardening, operation of nurseries or orchards, growth of commercial timber, grazing, recreational or hunting pursuits, or residential use. The regulations may

> also control the extent, manner, and times of the permitted uses, and may specifically prohibit unlimited cutting of forest growth, soil mining, or other activities detrimental to good conservation practices . . .

b. The statutory language clearly anticipates a variety of uses which "are not limited to" the enumerated list. The section goes on to provide that "(t)he regulations may also control the extent, manner, and times of the permitted uses, and may specifically prohibit . . . activities detrimental to good conservation practices."

c. The multiple uses outlined in HRS 183-41 reflect a weighing of long term environmental values against limited categories of human needs. For example, the long term protection of the watershed must be balanced with the need to withdraw water for domestic use. Likewise, a project which requires unique location within a conservation zone and benefits the larger public may be necessary while a project easily sited elsewhere might not be proper. For example, a hydroelectric dam which serves a larger population may be uniquely and properly located in a conservation district to take advantage of a waterfall; whereas a multitude of single family homes would be inappropriate even though both are similarly intrusive. The unique balancing depends upon more specific factors developed and authorized by the Board's zoning regulations.

d. Baseline studies and regulated exploration activities to observe, monitor, and measure a resource are a permitted use in the conservation district consistent with the provisions of HRS 183-41 and Title 13, Chapter 2 of the Department's Administrative Rules. (BLNR Conclusions of Law 8.1.1.2 CDUA No. HA 3/2/82-1463)

3. <u>DLNR Conservation Definition</u>:

a. The Board's administrative rules define conservation to mean:

> A practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural and scenic resources attendant to land . . . to ensure optimum long-term benefits for the inhabitants of the State. (DLNR 13-2-1)

b. This definition reiterates the balance of values and multiple use character of conservation lands. (BLNR Conclusions of law 8.1.1.3 CDUA No. HA 3/2/82-1463)

4. <u>Protection (P) Subzone Uses Allowed in Limited Subzone</u>

a. DLNR Administrative Rule 13-2-11 outlines permitted uses in the Protective subzone, Section 13-2-11 provides:

The following uses are permitted . . . : (1) _research_, recreational, and educational uses which require no physical facilities; (2) establishment and operation of marine, plant, wildlife sanctuaries and refuges, wilderness and scenic area, including habitat improvements; (3) restoration or operation of significant historic and archaeological sites listed on the national or state register; (4) maintenance and protection of desired vegetation . . . ; (5) programs for control of animal, plant, and marine population, to include fishing and hunting; (6) _monitoring, observing, and measuring natural resources_; (7) occasional use; and (8) governmental use not enumerated herein where public benefit outweighs any impact on the conservation district. [DLNR 13-2-11(c)(1-8)]

b. The research of baseline environmental conditions is clearly a permitted use in paragraph (b), subparagraphs (1), (6), and (7). The exploration activities authorized by this order are specifically tailored to research, monitor, observe, and measure the natural geothermal resources in a specific area, and are also permitted uses. As discussed below, the Board may set conditions consistent with the nature and purposes of the subzone to protect the environment, restore historical and archaeological sites, maintain and protect desired vegetation, and permit occasional uses within the overall purpose of the conservation district. (BLNR Conclusions of Law 8.1.2.2., CDUA No. HA 3/2/82-1463)

5. Conditional Use Definition:

a. DLNR Administrative Rule 13-2-1 defines "conditional use" to mean:

> . . . a use, other than a permitted use . . . which may be allowed by the Board under certain conditions as set forth in this chapter as determined by the Board. (DLNR 13-2-1)

b. Zoning regulations adopted by the Board outline standards comprising of 15 conditions, 4 guidelines, 4 possible deviations, and a governmental compliance requirement for conditional uses considered by the Board. (BLNR Conclusions of Law 8.1.2.3, CDUA No. HA 3/2/82-1463)

6. Purpose and Intent of Conservation District

a.

> In reviewing applications, the following guidelines shall apply: . . . (4) All applications shall meet the purpose and intent of the State's conservation district. [DLNR 13-2-21(b)(4)]

b. The Board has approved a number of water wells drilled for both exploratory and development purposes within both the protection and limited subzones of the conservation district.

c. Baseline and geothermal exploration activities are consistent with the definition and purposes of conservation in section 13-2-1, HRS 205-2; and HRS 183-41. (BLNR Conclusions of Law 8.2.1.1 CDUA No. HA 3/2/82-1463)

CONCLUSIONS OF LAW

a. That the DOWALD staff properly assessed the seven factors delineated in Act 296. Those seven factors were:

(i) The area's potential for the production of geothermal energy;

(ii) The prospects for the utilization of geothermal energy in the area;

(iii) The geologic hazards that potential geothermal projects would encounter;

(iv) Social and environmental impacts;

(v) The compatability of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

(vi) The potential economic benefits to be derived from geothermal development and potential related industries; and

(vii) The compatability of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the Board shall consider, if applicable, objectives, policies and guidelines set forth in part I of Chapter 205 A, and the provisions of Chapter 226,

b. Upon an assessment of these criteria, DOWALD properly concluded that based upon currently available information that approximately 11,745 acres of the Kilauea Middle East Rift Zone, Puna, Hawaii, were appropriate for designation as a geothermal resource subzone, as the assessment showed that this particular subzone demonstrated an acceptable balance among the criteria set forth in Act 296.

c. That the Board, after further examination of the evidence presented, finds that Campbell's proposed modification to the subzone proposal as seen on Campbell Exhibit 3 demonstrates an acceptable balance among the criteria set forth in Act 296 and takes into account the factor of geologic hazard and is thus, a more appropriate area for designation as a geothermal resource subzone and such modification shall be accepted by the Board.

d. That a contested case was not required for the designation process and that the hearing held by the Board of Land and Natural Resources was for the purposes of obtaining additional information to aid the Board in its decision whether or not to designate approximately 11,745 acres at Kahauale'a, Puna, Hawaii, as a geothermal resource subzone.

PROPOSED ORDER

The Board of Land and Natural Resources after assessing all of the information made available to them as related to the criteria set forth in Act 296, SLH 1983 finds that approximately 11,745 acres at the Kilauea Middle East Rift Zone, Puna, Hawaii, as outlined in Campbell's Exhibit 3, is appropriate for designation as a geothermal resource subzone.

It is hereby ordered that:

Approximately 11,745 acres at the Kilauea Middle East Rift Zone, Puna, Hawaii is hereby designated as a geothermal resource subzone.

Done at Honolulu, Hawaii, this _______ day of ________________, 1985.

BOARD OF LAND AND NATURAL
RESOURCES, STATE OF HAWAII

By ____________________________
SUSUMU ONO, Chairman

By ______________________________
MOSES W. K. KEALOHA

By ______________________________
ROLAND H. HIGASHI

By ______________________________
WENDELL Y. Y. ING

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing document was duly hand delivered and/or mailed to the persons named below at their last known address on December 4, 1985.

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BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone	G.S. NO. 9/26/85-5

PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW, DECISION AND ORDER OF THE DIVISION OF WATER AND LAND DEVELOPMENT

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NATURAL RESOURCES

CONTENTS

LIST OF ABBREVIATIONS

BLNR	for	Board of Land and Natural Resources
CDUA	for	Conservation District Use Application
DLNR	for	Department of Land and Natural Resources
DOH	for	Department of Health
DOWALD	for	Division of Water and Land Development
dB	for	Decibels
Ex.	for	Exhibit
EPA	for	Environmental Protection Agency
GRS	for	Geothermal Resource Subzone
HAAQS	for	Hawaii Ambient Air Quality Standards
HELCO	for	Hawaii Electric Light Company
HRS	for	Hawaii Revised Statutes
Ldn	for	Day-night noise levels
MW	for	Megawatts of Electrical Power
No.	for	Number
p.	for	Page
pp.	for	Pages
SLH	for	Session Laws of Hawaii
Trans.	for	Transcript
VCA	for	Volcano Community Association

I. FINDINGS OF FACT

A. Introduction

1. This contested case administrative proceeding dealt with the proposed designation of the Kilauea Middle East Rift Zone as a geothermal resource subzone (hereinafter "GRS").

2. The Kilauea Middle East Rift Zone is located between the western boundary of the Kamaili GRS and the eastern boundary of Campbell Estate's land at Kahaualea as shown on State Ex. 4, and the attached Figure 1.

a. The proposed GRS includes 11,745 acres, of which approximately 10,413 acres are zoned conservation and 1,332 acres zoned agricultural. (Written Testimony of Manabu Tagomori, p. 20)*

b. The conservation area is presently designated as the Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve. The extreme eastern and southeastern areas of this proposed GRS is zoned agricultural. (State Ex. No. 2, p. 42)

c. Property in the middle east rift zone is owned by two large area landowners, the State of Hawaii and Campbell Estate. Smaller holdings owned by various individuals are found in the eastern and southeastern areas of the proposed GRS in the agricultural classified lands. (State Ex. No. 2, p. 12)

d. At present approximately 11,064 acres are State-owned and 681 are privately owned. (Written Testimony of Manabu Tagomori, p. 20)

3. On December 12-19, 1984, the Board of Land and Natural Resources (hereinafter "BLNR") conducted a contested case proceeding to determine whether 5,300 acres of land at Kahaualea, Puna, Hawaii, located in the Kilauea Upper East Rift Zone should be designated a geothermal resource subzone.

4. Pursuant to its Decision and Order dated 12/28/84, BLNR instructed the Division of Water and Land Development (hereinafter "DOWALD") of the Department of Land and Natural Resources (hereinafter "DLNR") to assess the feasibility of designating the adjacent state and private lands situated at Puna, Hawaii, in the Kilauea Middle East Rift Zone as a possible geothermal resource subzone. (Decision and Order, G.S. No. 8/27/84-1)

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*All references to written testimony refer to the current contested case hearing, G.S. No. 9/26/85-5, unless otherwise noted.

5. DOWALD conducted an assessment of the Kilauea Middle East Rift Zone as a possible geothermal resource subzone and recommended its designation in Circular C-114 (State Ex. 2) and as shown on State Ex. 4.

6. DOWALD's assessment of the Kilauea Middle East Rift Zone utilized currently available information and incorporated all previous records relating to geothermal subzoning, exploration and development (Act 296, Section 3, SLH 1983; §205-5.2(C), HRS)).

7. On March 13, 1985 at Keaau, Hawaii, and May 15, 1985, Pahoa, Hawaii, DOWALD conducted public informational meetings on the proposed designation of the Kilauea Middle East Rift Zone as a geothermal resource subzone. (State Ex. 2, p. 6)

8. DOWALD also sought information by means of letter requests to persons previously involved in this matter and other persons who attended the public informational meeting. (State Ex. 2, p. 6)

9. DOWALD also met informally with many individuals, including consultants and the parties and witnesses involved in this proceeding, throughout the assessment and public hearing process to receive and seek information pertaining to the designation of the Kilauea Middle East Rift GRS. (Written Testimony of Manabu Tagomori, pp. 7 and 8)

10. The BLNR conducted a public hearing on September 26, 1985 at Pahoa, island of Hawaii, regarding the proposed designation of the Kilauea Middle East GRS. (State Ex. 1, p. iii)

11. A contested case proceeding on the proposed designation of the Kilauea Middle East Rift GRS was requested at the September 26, 1985 public hearing. (Transcript of Public Hearing held on 9/26/85)

12. The contested case proceeding was conducted by the BLNR on November 13-15, 1985, in Hilo, island of Hawaii, Hawaii.

13. The following DLNR records and files were incorporated in the November 13-15, 1985 contested case proceeding:

a. CDUA No. HA-3/2/82-1463 filed by the Estate of James Campbell.

b. All records of Public Informational Meetings and Transcripts of Public Hearings held as part of the Geothermal Subzoning Process for the Kilauea Middle East Rift Zone.

c. All transcripts and exhibits of the Contested Case Hearing G.S. 8/27/84-1 for designation of the Kilauea

Upper East Rift, Island of Hawaii, as a Geothermal Resource Subzone.

B. Issues

1. Act 296, SLH 1983 establishes the factors which shall be assessed in designating a geothermal resource subzone:

a. The area's potential for the production of geothermal energy;

b. The prospects for the utilization of geothermal energy in the area;

c. The geologic hazards that potential geothermal projects would encounter;

d. Social and environmental impacts;

e. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

f. The potential economic benefits to be derived from geothermal development and potential related industries; and

g. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

h. In addition, the board considered, where applicable, objectives, policies and guidelines set forth in part I of chapter 205A, the Hawaii Coastal Zone Management Act, and the provisions of chapter 226, the Hawaii State Planning Act. (§205-5.2(b), HRS; Chapter 13-184, Hawaii Administrative Rules of the DLNR; State Ex. 14, p. 3)

2. Designation of geothermal resource subzone shall be based upon the findings of the BLNR that a particular area best demonstrates an acceptable balance between the factors set forth in §205-5.2(b), HRS. (§205-5.2(d)(3), HRS)

3. At issue is whether the area described in State Exhibits No. 1 and 2 and proposed by DLNR demonstrates an acceptable balance between the factors set forth in §205-5.2(b), HRS and consequently should be designated as a geothermal resource subzone.

C. Act 296, SLH 1983, Factors - Potential for Production of Geothermal Energy

1. A Geothermal Resources Technical Committee was formed to assist the DLNR in locating potential geothermal resource areas for electrical power generation. The Committee members consisted of experts in the field of geothermal resources in Hawaii. (State Ex. 6, G.S. No. 8/27/84-1)

2. The statewide geothermal resource assessment, as mandated by Act 296, SLH 1983, was made on a county-by-county basis and was based on a qualitative interpretation of regional surveys and available exploratory drilling data going back 15 to 20 years. (State Ex. 6, G.S. No. 8/27/84-1)

3. The committee's assessment was based on the following types of geological, geophysical and geochemical data: (State Ex. 6, G.S. No. 8/27/84-1, pp. 3-5)

a. Ground water temperature data. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

b. Geologic age. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

c. Geochemistry. Ground water having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered ground water are anomalously high silica (SiO_2), chloride (Cl) and magnesium (Mg) concentrations. In addition, the evidence of above normal concentrations of trace and volatile elements such as mercury (Hg) and radon (Rn) may indicate leakage of geothermal fluids into nearby rock structures.

d. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of circulating ground water. Therefore rocks saturated with warm saline ground water have lower resistivities than rocks saturated with colder ground water.

e. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above-ambient ground temperatures.

f. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

g. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered, have substantially different magnetic properties than normal rock strata.

h. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

i. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

j. Self-potential. Self-potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea East Rift.

4. One of the most important conditions in a productive geothermal system is a permeable zone that permits adequate recharge of water to the reservoir. This criterion was considered and discussed with respect to all available information. Only exploratory drilling and flow testing of deep exploratory wells can confirm the permeability of an aquifer. (State Ex. 6, G.S. No. 8/27/84-1, p. 12)

5. The conclusions of the Technical Committee demonstrated that no single geothermal exploration technique, except for exploratory drilling, is capable of positively identifying a subsurface geothermal system. (State Ex. 6, G.S. No. 8/27/84-1, p. 12)

6. The selection of a high temperature resource area was based on the area's potential for production of electrical energy. The consensus of the Technical Committee was that present day technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than 3 km to make production of electrical energy feasible. (State Ex. 6, G.S. No. 8/27/84-1, p. xii)

7. Upon evaluation of the data and review of the list of percent probabilities, the Technical Committee identified seven High Temperature Potential Geothermal Resource Areas in the State of Hawaii. The criterion for selection of high temperature resource areas was agreed to be those areas having an assessed probability of at least 25% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km.

Area		Percent Probability
Haleakala S.W. Rift Zone, Maui	.....	25% or less
Haleakala East Rift Zone, Maui	.....	25% or less
Hualalai, Hawaii	....	35% or less
Mauna Loa S.W. Rift Zone, Hawaii	.....	35% or less
Mauna Loa N.E. Rift Zone, Hawaii	.....	35% or less
Kilauea S.W. Rift Zone, Hawaii	......	Greater than 90%
Kilauea East Rift Zone, Hawaii	......	Greater than 90%

(State Ex. 6, G.S. No. 8/27/84-1)

8. The Kilauea Middle East Rift is located within the Kilauea East Rift Zone adjacent to the lower east rift area now designated as the Kamaili GRS and the upper east rift area known as Kahaualea. (State Ex. No. 4)

9. Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. (State Ex. 6, G.S. No. 8/27/84-1, p. 8)

10. Commercially feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. (State Ex. 6, G.S. No. 8/27/84-1, p. 8)

11. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, it is found that there is a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km. (State Ex. 6, G.S. No. 8/27/84-1, p. 8)

12. The Kilauea Middle East Rift zone, located between the western boundary of the Kamaili geothermal resource subzone and the eastern boundary of Campbell Estate's land at Kahaualea is estimated at having a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 km. (Written Testimony of Manabu Tagomori, p. 10; State Ex. No. 2, p. 4)

13. The BLNR finds that the Kilauea Middle East Rift Zone, as proposed for GRS designation, possesses a high potential for a developable geothermal resource.

D. Act 296, SLH 1983, Factors - Prospects for Utilization of Geothermal Energy

1. Prior permit applications and developer interest expressed to DLNR and the County of Hawaii over the Kilauea Middle East Rift Zone, indicate that the prospects for utilization of the proposed subzone for geothermal exploration and development are good. (State Ex. 41, G.S. No. 8/27/84-1, p. 51)

2. The developer interest in the Kilauea East Rift Zone was stimulated by a request for proposal (RFP) issued in 1980 by Hawaiian

Electric Light Company, Inc. (HELCO) for geothermally generated electrical power to meet their projected power requirements in 1988. (Written Testimony of Robert Chuck, G.S. No. 8/27/84-1, p. 30)

3. HELCO desires to utilize geothermal energy as an integral part of their electrical resource production for the island of Hawaii. (Testimony of Alva Nakamura, Transcripts Vol. No. IV, p. 112-114)

4. True/Mid-Pacific Geothermal Venture has successfully passed the qualifying Phase I which required preparation of a comprehensive development plan for the Kilauea East Rift Zone. (Written Testimony of Robert T. Chuck, G.S. No. 8/27/84-1, p. 30)

5. If a firm commitment is made to install a 13 MW geothermal plant by the fall of 1988, HELCO can defer installation of an additional diesel generator until 1991. (VCA Ex. 12)

6. A deep water electrical transmission cable connecting the islands would significantly increase the demand for geothermal electricity. (State Ex. 14, G.S. No. 8/27/84-1; Written Testimony of Donald Thomas, p. 3)

7. Although the ultimate schedule for producing a commercial undersea cable is presently unknown, the design and construction of a prototype cable is projected for 1987 when a 30,000-foot length of test cable will be laid in the ocean channel between the Big Island and Maui. (Testimony of Stanley Tanno, G.S. No. 8/27/84-1)

8. In order to meet the projected electrical demand generated by the installation of an inter-island cable, geothermal resource exploration must begin immediately because of the time required to prove the geothermal resource. (Testimony of Donald Thomas, Transcript Vol. IV, p. 156-158)

9. HELCO plans to replace diesel-powered electricity with geothermal-powered electricity as geothermal electricity becomes available and the diesel-powered generators are retired. (VCA, Ex. 12; Testimony of Alva Nakamura, Transcript Vol. No. IV, p. 114)

10. HELCO is constructing a cross-island transmission line to transport electricity from east Hawaii, where geothermal resources are located, to west Hawaii where HELCO believes electrical demand may increase. (Testimony of Alva Nakamura, Transcript Vol. IV, p. 115)

11. Although HELCO's 5-year forecast projects the island of Hawaii's electrical demands as fairly stable, the actual electrical use has exceeded the current year's projections. (Testimony of Alva Nakamura, Transcript Vol. IV, p. 109-110)

12. If HELCO replaced all fossil-fuel energy resources with alternate energy resources, HELCO would require in excess of 100 megawatts of alternate energy electrical power. (Testimony of Alva Nakamura, Transcript Vol. IV, p. 127)

13. The BLNR finds there is a definite interest in the exploration, development and production of geothermal resource energy in the proposed Kilauea Middle East Rift GRS.

E. Act 296, SLH 1983, Factors - Geologic Hazards

1. The same volcanic activity along the Kilauea East Rift Zone which provides the ultimate source of geothermal heat is also a hazard to geothermal development. (State Ex. 12, G.S. No. 8/27/84-1 and p. vii, CDUA No. HA 3/2/82-1463, p. 4-47)

2. Potential geologic hazards include lava flows, pyroclastic fallout, ground cracks, earthquakes, subsidence, and tsunami. (Written Testimony of Manabu Tagomori, p. 11; Written Testimony of Donald Thomas, p. 4-5)

Lava Flow Hazards

3. Time and location of eruptions cannot be predicted with any degree of certainty. (State Ex. 6, G.S. No. 8/27/84-1, p. B-54; Testimony of Chuck Helsley and Richard Moore, G.S. No. 8/27/84-1)

4. The elevation of mildly sloping ridges north of the Kilauea Middle East Rift Zone axis offer protection from lava hazards. (Written Testimony of Manabu Tagomori, p. 11)

5. Several construction techniques are available which can mitigate the damage caused by lava flows; these include strategic siting, diversion berms and barriers, enclosed well cellars, evacuation planning, use of "bridge plugs", and decentralization of power plants to lessen the chance that one lava flow could damage a large capacity plant (State Ex. 12, G.S. No. 8/27/84-1, pp. 5, 12; Written Testimony of Donald Thomas, p. 5-6; Written Testimony of Gerald Niimi, p. 3-5).

6. Puu O'o is presently providing the least resistive path to the surface for intrusive magma in the Kilauea East Rift Zone. It is unlikely that eruptions will occur downrift while the Puu O'o eruptions continue. However, it is not possible to accurately predict the precise time and place of future activity. (State Ex. 2, p. 38)

7. Pipeline supports can be protected against flows with localized barriers or support structures. (State Ex. 12, G.S. No. 8/27/84-1, p. 7 and Testimony of Gerald Niimi, G.S. No. 8/27/84-1)

8. If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from lava flow hazard, wells or plants can be sufficiently fortified to withstand almost

any lava flow (Mullineaux and Peterson, 1974). (State Ex. 12, G.S. No. 8/27/84-1, p. 6)

9. Comprehensive evacuation plans can be designed to assure worker safety. Warning time prior to inundation can be as little as one hour (Moore, 1984) to eruption. Procedures can be established to protect equipment. Multiple access roads can be provided in the event one gets covered by a flow. (State Ex. 12, G.S. No. 8/27/84-1, p. 7; Written Testimony of Gerald Niimi, p. 4-5)

10. The developers can coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory) and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. The developers have been giving this area their attention. (State Ex. 12, G.S. No. 8/27/84-1, p. 7)

11. Trip wires, placed in the expected lava flow paths, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan (Niimi, 1984). (State Ex. 12, G.S. No. 8/27/84-1, p. 7)

12. Well heads and valves will not melt when covered by lava. (Campbell Ex. 2, G.S. No. 8/27/84-1, p. 4)

Hazards from Pyroclastic Fallout

13. The weight and depth of pyroclastic fallout can be appreciable as far as even 500 or 1,000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones that may be tens of meters high. Smaller particles can form a long, narrow blanket many feet thick downwind of the vent. (State Ex. 12, G.S. No. 8/27/84-1, p. 2)

14. Protecting structures or machinery against damage by pyroclastic fallout can be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong, having a sufficient pitch so that pyroclastic fallout does not accumulate. (State Ex. 12, G.S. No. 8/27/84-1, p. 7)

Hazards from Ground Cracking and Subsidence

15. Ground cracking and subsidence related to magma movements is concentrated in the volcanic rift zones which are clearly defined and narrow features along the entire Kilauea East Rift Zone. (State Ex. 12, G.S. No. 8/27/84-1, pp. 3, 22, 35)

16. Most cracks are vertically pitched making it unlikely, but possible, that a vertical crack would intercept a vertical well bore. (State Ex. 12, G.S. No. 8/27/84-1, pp. 3, 4)

17. Contingency planning would include the best available methods for sealing a well bore should a crack intercept a producing well. (Written Testimony of Manabu Tagomori, p. 11)

18. Tectonic ground cracking is usually localized in definable zones such as in the Hilina and Koae fault systems. (State Ex. 12, G.S. No. 8/27/84-1, p. 3)

19. Any cracks that develop below the caprock in a geothermal reservoir will not be a problem. (Testimony of Dallas Jackson, G.S. No. 8/27/84-1)

20. A fault could intersect a well-bore without causing any damage. The fault could seal off the well or the faulting could crimp the end of the casing and not allow the fluids to escape. (Testimony of Dallas Jackson, G.S. No. 8/27/84-1)

21. In Hawaii, subsidence from geothermal fluid withdrawal is not likely to be a problem, since the islands are generally composed of self-supporting basaltic rock. (State Ex. 2, p. 41)

Hazards from Earthquakes

22. The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 Km southwest of Kalapana. (State Ex. 2, p. 39)

23. Most earthquakes in Hawaii are volcanic; resulting from near-surface magma movements. They are small in magnitude and usually cause little direct damage. (State Ex. 12, G.S. No. 8/27/84-1, p. 4)

24. Geothermal power plants could be constructed to withstand an earthquake of 7.5 magnitude. (State Ex. 12, G.S. No. 8/27/84-1, p. 8)

25. Geothermal facilities can be designed to resist earthquakes which occur within normal ranges in Hawaii. (Testimony of Joe Kubacki, G.S. No. 8/27/84-1)

26. A November 1983 earthquake registering 6.6 on the Richter scale located in the Saddle area between Mauna Loa and Kilauea did not cause any damage to the HGP-A facilities. (Testimony of Richard Moore, G.S. No. 8/27/84-1)

27. Earthquakes are more frequent south of the east rift zone as substantiated by data collected by the Hawaiian Volcano Observatory. (Written Testimony of Manabu Tagomori, p. 12)

Tsunamis

28. Tsunami hazard is localized to a zone of land at most 2 km wide around the coast, and at elevations below about 75 feet. (State Ex. 2, p. 41)

29. This will not be a hazard to developments in the proposed Kilauea Middle East Rift GRS as elevations are generally above 1400 feet. (State Ex. 2, p. 41)

Risk of Loss from Geologic Hazards

30. Geothermal development investors bear the economic risk of loss resulting from geologic hazards. Consequently, developers have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity. Policy regarding assigning and clarifying risks of loss may be implemented by imposing conditions to be met by development investors prior to the granting of a geothermal resource permit by the State (conservation district) or Counties (urban, rural, or agriculture districts). (State Ex. 12, G.S. No. 8/27/84-1, pp. 8, 9; Written Testimony of Gerald Niimi, p. 3)

31. The BLNR finds that the geologic hazards associated with geothermal development in the proposed Kilauea Middle East Rift GRS can be mitigated by developer action and subsequent governmental permitting conditions.

F. Act 296, SLH 1983, Factors - Social and Environmental Impacts

1. Social and environmental concerns include air emissions, liquid effluents, noise, impact to lifestyle, culture and community setting, aesthetics, and impact to flora and fauna. (Written Testimony of Manabu Tagomori, p. 13; Written Testimony of Donald Thomas, p. 6; Written Testimony of Gerald Niimi, p. 6-9)

Air Emissions

2. The health aspects of air emissions resulting from geothermal resource development involve the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds. (State Ex. 8, G.S. No. 8/27/84-1, p. 1)

3. Quantification of pre-development concentrations of naturally occurring emissions in geothermal rift zones is essential in order to assess any future changes in emission concentrations resulting from development of the geothermal resources. (State Ex. 10, G.S. No. 8/27/84-1, p. 26)

4. Quantification has been undertaken by the State Department of Planning and Economic Development in a two-year environmental baseline survey of the Kilauea East Rift Zone from 1982 to 1984. (State Ex. 10, G.S. No. 8/27/84-1, p. 26)

5. The principal parameters measured in this study include atmospheric concentrations of particulate material, sulfur dioxide gas, hydrogen sulfide gas, chlorine gas, carbon monoxide gas, elemental mercury vapor, radon, elemental and organic content of particulate material, rainwater pH, elemental and anionic content of rainwater, and wind speed and directions. (State Ex. 10, G.S. No. 8/27/84-1, p. 26)

6. The study stated that the environmental risks are due primarily to atmospheric emissions of noncondensing gases. Hydrogen sulfide, particulate sulfate from the atmospheric oxidation of hydrogen sulfide, benzene, mercury, and radon are considered to be the more significant noncondensing gases from a health standpoint. (State Ex. 10, G.S. No. 8/27/84-1, pp. 15, 16)

7. The results of the Environmental Baseline Survey indicate the following ambient conditions (State Ex. 10, G.S. No. 8/27/84-1, pp. 28, 30):

a. Total Suspended Particulates (TSP) are very low and generally consist of sea-salt aerosal, road and soil dust, volcanic emissions, diesel exhaust and organic matter.

b. Sulfate particulate matter, and under certain conditions heavy metals contained in particulate matter can be related to volcanic emissions.

c. Current hydrogen sulfide and chlorine gas levels are very low and well below biological impact levels.

d. Occasional short-term hydrogen sulfide episodes at modest concentrations, but of short, less than a day, duration have been observed.

e. Sulfur dioxide concentrations due to volcanic activity can exceed standard values, values typical of urban areas, and human health and plant impact values for days at a time. Higher SO_2 values have been measured in the upper part of the Rift Zone than in the lower portion. In the absence of volcanic impact, SO_2 values are low.

f. Rainwater in Puna and Kau is slightly acidic. Acidification is due not only to volcanic emissions but also to long-range transport from sources across the Pacific.

g. All trace elements measureable were found to be below drinking water quality standards.

h. Ambient mercury and radon values were more or less typical of atmospheric values nationwide. However, the impact of volcanic emissions on the atmospheric radon content could be seen by noting the higher values measured at the site closest to the current eruption area in Kahaualea.

8. The State Department of Health (DOH) has proposed Ambient Air Quality Standards to control H_2S emissions from geothermal wells and power plants (Chapters 11-59 and 11-60, Hawaii Administrative Rules of DOH). (Written Testimony of Manabu Tagomori, p. 12, and State Ex. 2, p. 19)

9. Chapter 11-60, Hawaii Administrative Rules, is to be amended by adding a new section 11-60-23.1 covering allowable emissions of particulates and hydrogen sulfide for geothermal wells and emissions of hydrogen sulfide only from geothermal power plants. (State Ex. 10, G.S. No. 8/27/84-1, p. 31)

10. The recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the noncondensable gases. (State Ex. 10, G.S. No. 8/27/84-1, p. 30)

11. Use of the Stretford system would enable facilities to comply with the proposed State Department of Health air quality standard for geothermal developments since this standard requires 98% of the H_2S present to be removed. (State Ex. 10, G.S. No. 8/27/84-1, p. 30)

12. Given the characteristics of the HGP-A reservoir fluids and the available emission abatement technology which would be required to comply with proposed State air quality standards, geothermal facility cooling tower emissions would not be toxic and the plume would consist entirely of water vapor. Brine from the plant will be injected back into the geothermal reservoir. (State Ex. 10, G.S. No. 8/27/84-1, p. 30)

13. Abatement of Radon-222 is unnecessary since the level emitted from the power plant is lower than most indoor levels where cement emits radon in most buildings. (State Ex. 10, G.S. No. 8/27/84-1, p. 30)

14. The study, "Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii," January, 1984, prepared for the U.S. Environemental Protection Agency by Dames & Moore on the Best Available Control Technology (BACT) for emission abatement was utilized in the assessment. (State Ex. 8, G.S. No. 8/27/84-1, p. 3)

15. H_2S, particulate and trace element emission rates were all developed from data gathered at HGP-A and assuming the emission controls described above. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality. Based on these calculations, potential H_2S emissions during normal power plant operations for the development scenarios [25MW and 50MW] described in this report are well below the proposed Hawaii Ambient Air Quality Standard (HAAQS) for H_2S. (State Ex. 8, G.S. No. 8/27/84-1, p. 4)

16. H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emission control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities. (State Ex. 8, G.S. No. 8/27/84-1, p.4)

17. Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this "BACT" study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds. (State Ex. 8, G.S. No. 8/27/84-1, p. 4)

18. Hydrogen sulfide abatement technology such as the Stretford and burner-scrubber system will reduce the emissions from geothermally generated electricity to levels far below that generated by more conventional fossil fuel electrical energy production currently in operation today in Hawaii. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-15; Written Testimony of Donald Thomas, p. 7; Written Testimony of Gerald Niimi, p. 8-9))

19. Kilauea Volcano normally emits 200 tons a day of sulfur dioxide and the contribution of sulfur dioxide from a project such as that proposed at Kahaualea at full development would only be a fraction of 1 percent of that amount. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-16)

20. The emissions of sulfur, mercury, and other volcanic gases are a continuous process at Kilauea, the rift zone, and the adjacent forest and its inhabitants have long been exposed to lower levels of these potentially toxic emissions and intermittently to higher levels. Exposure to significant levels of geothermal gases are part of the norm for native Hawaiian plants and animals. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-20)

21. "The Puna Community Survey", prepared in 1982 by SMS, Inc. for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, reported that only one-fifth of the total survey respondents felt they had been affected by the geothermal wells in Puna, on the Hawaii Island. (State Ex. 8, G.S. No. 8/27/84-1, p. vii)

22. In the "Puna Speaks" case, where HGP-A shutdown was requested by some Puna residents, the U.S. District Court Judge ruled that the plaintiffs did not prove their case in suit as no causation was established between the well emissions and alleged maladies. (State Ex. 8, G.S. No. 8/27/84-1, p. 3)

Liquid Effluent

23. Almost all geothermal fluids have a total dissolved solids content greater than 1000 ppm. (State Ex. 10, G.S. No. 8/27/84-1, pp. 12, 13)

24. All geothermal fluids will be disposed of by reinjection into the geothermal reservoir. (State Ex. 10, G.S. No. 8/27/84-1, pp. 12, 13)

25. Surface disposal will not be permitted. (State Ex. 10, G.S. No. 8/27/84-1, pp. 12, 13)

26. None of the rift zones considered contain perennial streams. (State Ex. 10, G.S. No. 8/27/84-1, pp. 12, 13)

27. Impact to surface waters is expected to be minimal. (State Ex. 10, G.S. No. 8/27/84-1, pp. 12, 13)

28. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. (State Ex. 10, G.S. No. 8/27/84-1, p. 13)

29. Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. (State Ex. 10, G.S. No. 8/27/84-1, p. 13)

30. Ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer and a surface casing is set and cemented through a competent subsurface formation below the basal lens. (State Ex. 10, G.S. No. 8/27/84-1, p. 13)

31. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the ground water aquifer. (State Ex. 10, G.S. No. 8/27/84-1, pp. 13, 14)

32. Common practice is to inject residual geothermal fluids back into a geothermal reservoir for disposal, thus isolating spent fluids from drinking water supplies. Injection wells like geothermal wells are drilled past the ground water aquifer and cased so that no leakage to an aquifer can occur. (State Ex. 10, G.S. No. 8/27/84-1, p. 26)

33. The State DOH has established an Underground Injection Control program designed to protect the state's underground sources of drinking water (Chapter 11-23). These laws will regulate underground injections of geothermal fluids such that underground sources of drinking water are not polluted. (State Ex. 2, p. 26)

Noise Aspects

34. Although noise levels associated with geothermal energy development and operation are comparable with those industrial or electrical plants of similar size, plant construction and operation in a

quiet rural area are a potential noise factor which can be controlled and monitored. (State Ex. 8, G.S. No. 8/27/84-1, p. 4; Written Testimony of Gerald Niimi, p. 6-7)

35. The source of noise impact from a proposed geothermal project would arise from (a) construction of roads, pipelines, and buildings; (b) geothermal well-drilling and testing or venting; and (c) geothermal power plant operations. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

36. During the initial phases of field development; persons in the immediate vicinity of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site. (State Ex. 11, G.S. No. 8/27/84-1, p. 8)

37. Noise generated by construction activity will involve the use of standard construction equipment such as bulldozers, trucks, and graders operating in the same manner, and over a limited time period as any other typical project. No unusual noise events of long duration are invovled. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-29)

38. Within 100 feet of the drill rig, noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler. (State Ex. 11, p. 8; Written Testimony of Gerald Niimi, p. 6)

39. Noise levels projected for the anticipated power plants are expected to be low and should result in slightly audible or inaudible levels at most receptor sites. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

40. Taking all major noise sources into account, the continuous noise level of 75 dBA at 100 feet is considered readily achievable for power plants. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-30)

41. Ambient or background noise refers to the noise levels which presently exist in the environs of any project site at locations where people reside, play or work and sometimes is produced by the people themselves. The existing exterior ambient noise levels at residences in the environs of the proposed geothermal operations are dictated largely by the sounds of nature and by the traffic on Volcano Highway as well as by traffic on local roads. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-22)

42. The impact and intrusiveness of the noise of geothermal operations is dependent on the meteorological conditions; the intensity of the noise source; the sound propagation conditions existing between the source and listener; the ambient or background noise at the receptor; and the activity at the receptor area at the time of the noise

event. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-21)

43. As a project progresses, noise propagation information can be obtained and would serve as guidance for the design of noise mitigation measures required of the power plants, particularly for power plants located closer to noise-sensitive residential and park areas. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-29)

44. Ambient noise levels are often expressed as day-night noise levels (Ldn) where a 10 dB reduction is given for noise levels during the nighttime period between generally 10 p.m. to 7 a.m. The long-range strategy of the Environmental Protection Agency (EPA) is to achieve a goal of 55 Ldn (45 dBA nighttime) which will ensure protection of public health and welfare from all adverse effects of noise based on present knowledge. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-22).

45. The EPA "Protection Noise Level" document's recommended levels, defined by a negotiated scientific consensus that was developed without concern for economic and technological feasibility, are intentionally conservative to protect the most sensitive portion of the American population, and include an additional margin of safety. The levels could be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-23)

46. In May of 1981, the County of Hawaii Planning Department issued a set of "Geothermal Noise Level Guidelines" to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. (State Ex. 8, G.S. No. 8/27/84-1, p. 5)

47. The County of Hawaii geothermal noise level guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted. (State Ex. 11, G.S. No. 8/27/84-1, p. 8)

48. The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. (State Ex. 11, G.S. No. 8/27/84-1, p. 8)

49. The type of housing found in Fern Forest, Volcano Village, etc., will result in noise reduction from outside to inside of at least 15 dB. Thus, an outside noise level of 45 dBA will reduce to an inside level of 30 dBA or less, which is less than the EPA's 32 dBA

level for sleep modification. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-23)

50. The BLNR finds that any adverse sociological and environmental impacts from air emissions, liquid effluent, and noise associated with geothermal development can be effectively mitigated utilizing current technology.

Lifestyle, Culture, and Community Setting

51. The Puna area in which the Kilauea Middle East Rift Zone is located has the most information and input to date on the lifestyle, culture and community setting aspects related to geothermal development, since several geothermal-related surveys have been conducted there. This information may be applicable to other localities. (State Ex. 8, G.S. 8/27/84-1, p. 7)

52. In April 1980, 11,775 persons living in Puna, constituted roughly 13 percent of the Big Island's population. In district size and population, Puna ranks third after South Hilo and North Kona. Puna's population density of 23 persons per square mile is the same for the County of Hawaii as a whole. Within the Puna District, roughly 20 percent (2,246) of the residents were living in the towns of Keeau, Mountain View, and Pahoa. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/83, p. 4-44)

53. The small magnitude of change in lifestyle and social inter-action that may be brought about by new residents may be a small part of the lifestyle, culture and community and traffic changes already taking place in the area as a result of the influx of new residents in recent years. (State Ex. 8, G.S. No. 8/27/84-1, p. 14)

54. The Hawaiian Civic Club in Kau has stated its support of the proposed geothermal resource subzones. They have stated that while there are things that should be preserved, there is a lot of things that sometimes need to be given up for the betterment of their own Hawaiian children and families. (Testimony of Anna Cariaga, Pahala Public Hearing, 9/26/85)

55. In addition, other Hawaiians who share the love of this land with others, cognizant of their heritage and traditions, feel their ancestors would be proud to know that they are trying to use our natural resources in the best way possible. The Hawaiians of times past, with their astute knowledge of all things and through the proper observance of established laws, used all of the natural resources available in their limited way to do the most good for the most people. (Testimony of George Jenkins, Public Hearing 9/26/85)

56. Some Hawaiians also identify themselves as the bloodline of a mythical legendary goddess named "Pele" and believe that their existence and theology is threatened by the potential changes that may result from geothermal development. They also believe that geothermal development may forever extinguish or destroy essential parts of

Hawaiian heritage, culture and religion. (State Ex. 2, p. 13; Testimony of Emmett Aluli, Transcript Vol. V, VI)

57. The recognition and use of geothermal energy, however, has been recorded in the early history of the Hawaiian Islands by the Reverend William Ellis whose journal has been published in many editions. Explorers identified numerous fumaroles and thermal features on Kilauea and Mauna Loa volcanoes as early as 1825. (State Ex. No. 2, p. 13)

58. Early Hawaiians are recorded using steam emanating from fissures along the rift zone for personal uses as well as religious uses. William Ellis notes that the ground in the vicinity of Kilauea throughout the whole plain was so hot that those who came to the mountains to gather wood and to fell trees and hollow them for canoes "always cooked their own food, whether animal or vegetable, simply by wrapping it in fern leaves and burying it in the earth", a method quite similar to the Hawaiian imu. (State Ex. 2, p. 13)

59. At Kilauea on Hawaii, Handy and Handy, in their "Native Planters in Old Hawaii" describes how whole trunks of hapu'u pulu (fern trees) were thrown into steam fissures, covered with leaves, and when cooked, were split open and the starch core used as food for pigs. (State Ex. 2, pp. 13-14)

60. The use of warm springs also was not unknown, since Ellis notes that at Kawaihae at the shore, warm springs provided a refreshing morning bath. Although the citation indicates a location removed from the Kilauea Rift Zone, the spring water is described as being "comfortably warm" and "probably impregnated with sulfur". He also notes medicinal qualities were ascribed to it by those who used it. (State Ex. 2, p. 14)

61. There have been no studies of the impact of exploration on native Hawaiian cultural or religious values and practices. The BLNR and parties did conduct a site visit accompanied by a guide knowledgeable about the traditions and practices in the area on December 11, 1982. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact, 2/25/83, p. 4-41)

62. Mr. Don Mitchell, noted author on Hawaiian history, does not believe that ancient Hawaiian beliefs were specifically against the use of steam, but that it is only a recent interpretation of Hawaiian theology. He believes that steam is not referred to in early discussions of Pele but that lava and volcanic eruptions are more closely associated to Pele. (State Ex. 8)

63. The religious concerns of native Hawaiians command respect, and care could be exercised to enhance and not harm genuine religious aspects of the area. (CDUA No. HA 3/2/82, BLNR Findings of Fact, 2/25/83, p. 7-32)

Historic and Archaeological Values

64. Development of geothermal facilities by site clearing and facility construction runs the risk of destroying historical and archaeological sites and artifacts. (State Ex. 10, G.S. No. 8/27/84-1, pp. 34, 35)

65. Estimates of likely impacts can be accomplished by (1) plotting the location of known archaeological sites within and nearby proposed subzones, (2) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, and (3) by archaeological reconnaissance surveys on site. (State Ex. 10, G.S. No. 8/27/84-1, p. 34)

66. Prehistoric cultural activities and features such as foot trails, upland taro patches and planting areas, a pulu factory, and other sites have been reported in the area adjacent to the proposed subzone. As geothermal development occurs, each new increment of land area could be archaeologically surveyed by a qualified archaeologist after specific sites for development activity are determined and before land clearing begins. If archaeological sites are found, they could be described and assessed as to significance, and measures taken to ensure avoidance or mitigation of potential impacts from geothermal developments. (State Ex. 2, p. 12)

67. The BLNR finds that any adverse sociological impacts to the lifestyle and culture of the community and historic and archaeological values associated with geothermal development can be mitigated by sensitive and careful consideration of the communities' needs in subsequent permitting processes.

Scenic and Aesthetic Values

68. Geothermal resource areas are located in remote wilderness areas, some of which are heavily forested, and development of geothermal facilities may represent a visual intrusion. (State Ex. 10, G.S. No. 8/27/84-1, p. 36)

69. In some areas with potential geothermal resource development, the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--however, consideration of aesthetic aspects could include careful siting, tasteful design, and effective landscaping. (State Ex. 2, p. 14)

70. Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures, towers and plants with colors to blend in with the natural setting. (State Ex. 2, p. 14)

71. Depending upon the terrain within and adjacent to a proposed project site, an analysis of view corridors may be required in environmental assessments for the development of specific sites within a geothermal resource subzone during the subsequent permitting process. (State Ex. 2, p. 15)

72. Estimates of visual impact are accomplished by preparing an area-wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen. A terrain analysis of visual impacts was completed for the preparation of the Kahaualea Environmental Impact Statement. (State Ex. 10, G.S. No. 8/27/84-1, p. 36)

73. A similar terrain analysis could be included in environmental impact assessments for the development of specific sites within a geothermal resource subzone during the subsequent permitting process. (State Ex. 10, G.S. No. 8/27/84-1, p. 36)

74. The terrain analysis prepared for the Kahaualea EIS indicated that power plants would be visible from many areas of the barren lava fields. (State Ex. 10, Appendix E, G.S. No. 8/27/84-1, pp. E-3 and E-4)

75. No correction for trees has been incorporated into these perspectives. If trees are included in the terrain analysis, then potential visual intrusions could be further mitigated. (State Ex. 10, G.S. No. 8/27/84-1, p. E-4)

76. Even when the power plants are visible, they are at distances of one to six miles and thus they would not be significant intrusive features with proper design and construction considerations. In no case are they expected to be seen as a silhouette on the horizon, but instead, they would be a feature in the middle to the far distant background. (State Ex. 10, G.S. No. 8/27/84-1, p. E-4)

77. It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the east rift zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, no visible vapors are expected from the cooling towers. (State Ex. 10, G.S. No. 8/27/84-1, p. E-4)

78. The preservation of natural beauty and aesthetics could be achieved by well-planned siting, landscaping and well-designed plant architecture. (State Ex. 8, G.S. No. 8/27/84-1, p. 14)

79. The following opinions were given during the Puna Community Survey by SMS, Inc. in April 1982:

a. Most Puna residents have noticed existing geothermal wells, but few have been personally affected by them. Two-thirds of the survey respondents reported having seen a well, but only 18 percent said there had been any impact on themselves or a household members.

b. When described as "generating electricity from the volcano's steam," geothermal energy production was judged "good for Puna" by 62 percent of the sample and "bad for Puna" by 21 percent. In Kapoho-Kalapana, the area potentially most affected, the figures were 47 percent in favor and 30 percent opposed.

c. Roughly half of the respondents said they thought that "using steam wells to make electricity--without any other industrial development" would be a good idea for Puna. A much larger majority supported the sort of agriculture-related light industry which could be aided by geothermal resources (e.g., fruit drying or hot houses), while a distinct minority in Puna thought geothermal-powered heavy industry such as manganese nodule processing would be good for the district.

d. Asked to respond to ten different possible forms of economic and physical development, there was more than 90 percent approval for the general (if vague) concept of "more jobs" and for the idea of more diversified agriculture. Ag-related light industries--like fruit drying, hot houses, and aquaculture--was supported by 83 percent, and raising crops to produce ethanol fuel earned 63 percent approval.
(State Ex. 8, G.S. 8/27/84-1, p. 2)

80. The BLNR finds that any adverse scenic and aesthetic impacts to the area and surrounding community resulting from geothermal development can be effectively mitigated utilizing current technology and development controls at subsequent permitting processes.

Impact to Native Forest

81. Potential environmental impact on the flora of the Kilauea East Rift zone, as with other rift zones, was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping which incorporates information on the extent of canopy cover, height of canopy, understory composition and vegetation association type. (State Ex. 10, G.S. No. 8/27/84-1, p. 6)

82. A detailed vegetation survey of Puna forests conducted by J.D. Jacobi in 1983, indicates that the highest quality native vegetation is located uprift and outside the proposed Kilauea Middle East Rift GRS; however, the western portion of the proposed GRS does contain some of this vegetation. (State Ex. 2, p. 30)

83. This vegetation consists of wet ohia forest with mixed native subcanopy trees with a tree fern native shrub understory. (State Ex. 2, p. 30)

84. Vegetation in the southwestern portion of the GRS is classified as closed canopy, wet ohia forest with mixed native subcanopy trees and a tree fern native shrub understory with some introduced shrubs and ferns. There are also small sections of ohia kukui forest present in the southwest section. (State Ex. 2, p. 30-32)

85. The northern portion of the proposed GRS include a large section of open canopy, wet ohia forest with mix native sub-canopy trees, and a tree fern native shrub understory with some introduced shrubs and ferns. The southeastern section contains wet pioneer ohia community. A significant portion of the proposed GRS is bare recent lava. (State Ex. 2, p. 32)

86. Disruption of native forest ecosystems is a potential environmental impact resulting from the development of geothermal energy. (State Ex. 10, G.S. No. 8/27/84-1, p. 4)

87. Native forests are paticularly vulnerable to invasion by exotic species along roadways or other cleared areas. Once such an invasion begins, native forest is gradually altered and non-native species which intially invaded along relatively narrow corridors spread and multiply. (State Ex. 10, G.S. No. 8/27/84-1, p. 4)

88. Major geothermal development, with an attendant network of roads and construction corridors may be expected to dissect and eventually degrade undisturbed native forest by opening it to invasions by weedy species. (State Ex. 10, G.S. No. 8/27/84-1, p. 4)

89. Impact to native forest ecosystems can be mitigated through careful siting of facilities, access roads, pipe and powerline corridors so as to avoid damage to biologically valuable forest. (State Ex. 10, G.S. No. 8/27/84-1, p. 4)

90. Air quality standards will assure that geothermal emissions will be well below amounts released during eruptions and probably below amounts necessary to cause damage to native flora. (Lamoureux, written testimony, G.S. No. 8/27/84-1, p. 4)

Impact to Endangered Plant Species

91. A recent flora and fauna survey, "Puna Geothermal Area Biotic Assessment", published in April 1985 by the University of Hawaii, Department of Botany, indicates that a number of plant species found within the east rift zone area are listed as Category 1 candidate species for listing as endangered by the U.S. Fish and Wildlife Service. (State Ex. 2, p. 32; Written Testimony of Charles Lamoureux, p. 4-6)

92. Category 1 species is one for which the U.S. Fish and Wildlife Service has sufficient information to support the biological appropriateness of listing as endangered, but for which data still need

to be collected concerning the environmental and economic impacts of listing the species and designating a critical habitat for it. (State Ex. 2, p. 32)

93. Of the nineteen Category 1 species collected in the University's survey, only two are found within the proposed GRS, a medium sized tree, Bobea timonioides and Cyanea tritomantha. (State Ex. 2, p. 32)

94. Bobea timonioides, also known as 'akakea, is found in Ohia forest types and was sighted at three locations in the proposed GRS, at one site in the designated Kapoho GRS, and at two sites along the lower rift zone outside the proposed GRS. Cyanea tritomantha var. tritomantha, known as 'aku'aku, was sighted in the northeast corner of the proposed GRS. (State Ex. 2, p. 32)

95. The endemic fern, Adenophorus periens, also is a category 1 species and was sighted mostly outside of the proposed GRS to the west and north. (State Ex. 2, p. 32; Written Testimony of Charles Lamoureux, p. 5-6)

96. The area within the proposed subzone contains a significant percentage of introduced plant species, consequently, the amount of change which would result from the introduction of alien plants as a consequence of human activities in this area is likely to be less significant than that which would occur in more pristine areas. (Written Testimony of Charles Lamoureux, pp. 2-4, 6-7)

97. The dissected nature of the vegetation in the proposed Kilauea Middle East Rift GRS allows for geothermal development to proceed in ways which would enable development to avoid the most sensitive areas of the forest. (State Ex. 2, p. 32; Testimony of Charles Lamoureux, Transcript Vol. VI, p. 99)

98. Mitigation measures can be taken to minimize risks to native forests and endangered plant species. (State Ex. 2, p. 32; Ex. 3, p. 116; Written Testimony of Charles Lamoureux, p. 6-7)

99. As a result of lava flow inundation as well as the introduction of exotic plant species, the lower southwest corner of the proposed subzone is not considered a biologically sensitive area except those native forest areas categorized as category (1) and (2) forests in the Puna Geothermal Area Biotic Assessment, State Ex. 3. (State Ex. 3; Testimony of Charles Lamoureux, Transcript Vol. VI, p. 101-102)

Impact to Endangered Native Birds

100. Endangered birds sighted on the Kilauea middle east flank include the O'u, the I'o (Hawaiian Hawk), and the Nene (Hawaiian goose). (State Ex. 2, p. 33)

101. O'u sightings have been reported west and north of the proposed Kilauea Middle East Rift GRS and, as noted in the University's fauna survey, usually above the 3000-foot elevation. (State Ex. 3, p. 77)

102. The authors of the Hawaii Forest Bird Recovery Plan have recommended and the U.S. Fish and Wildlife Service has approved an essential habitat for the O'u which is believed to be necessary for the O'u to be restored to non-endangered status. (State Ex. 2, p. 33)

103. The lower habitat boundary has been set at 2000-foot elevation, and as such includes only a small portion of the proposed GRS as shown on Figure 9 of Circular C-114. Portions of this area have been recently inundated by lava flows. (State Ex. 2, pp. 33, 35; VCA Ex. 6)

104. In recent years a few scattered sightings of O'u have been made in the Kilauea East Rift Zone. It is not known whether a breeding population of 'O'u still exists in the project area. It is probably the rarest native bird which now occurs there, however. (State Ex. 3, pp. 1, 113)

105. There has been no siting of the endangered 'O'u, a native forest bird, within the Kilauea Middle East Rift GRS. (Transcript of Cross-examination of Sheila Conant, Vol. II, p. 66)

106. The I'o is a roaming bird which has been sighted throughout the Puna area, over a wide range of ecosystem types including agricultural lands. The effects of well emissions on 'I'o are not clear. 'I'o population size and breeding activities around geothermal sites could be monitored. (State Ex. 2, p. 33; State Ex. 3, p. 115)

107. The primary range of the Nene is approximately 10 km to the west of the proposed Kilauea Middle East Rift GRS. Nene are not known to nest in the proposed GRS. Their present range is thought to be from 3800 to 8000 feet on the slopes of Mauna Loa. (State Ex. 2, p. 36)

108. Mitigation measures, including siting of well sites and power plants to avoid nesting sites, could be implemented and monitored during subsequent permitting processes. (State Ex. 2, p. 33; Ex. 3, p. 115)

Invertebrates

109. Invertebrates such as fruit flies (giant Drosophila spp), tree snails (Partulina spp), and special cave-adapted fauna residing in lava tubes are known to exist in the Mauna Loa East Rift

and the Kilauea East Rift Zones. (State Ex. 10, G.S. No. 8/27/84-1, pp. 11, 12)

110. Lava tube ecosystems are dependent on intact penetrating ohia root systems for their moisture supply and are therefore vulnerable to any development which results in forest clearing. (State Ex. 10; G.S. No. 8/27/84-1)

111. Impacts to these species may be largely avoided by avoiding siting facilities in native forests areas. (State Ex. 10; G.S. No. 8/27/84-1)

112. Testimony regarding the Hawaiian Drosophila indicated that no surveys have been conducted in the Kilauea Middle East Rift GRS and that while there may be unique species in the area, there are also unique species of drosophila found all over the State of Hawaii. (Testimony of Dr. Kenneth Kaneshiro, Transcript Vol. II, pp. 28, 29)

113. The BLNR finds that any adverse environmental impacts to native forests, endangered plant and bird species and native invertebrates associated with geothermal development can be effectively mitigated by careful siting and the location of geothermal facilities controlled during subsequent permitting processes.

G. Act 296, SLH 1983, Factors - Compatibility of Geothermal Development and Potential Related Industries with Present Uses of Surrounding Land and Those Uses Permitted Under the General Plan or Land Use Policies of the County in Which the Area is Located

1. Urban, rural and agricultural state land use districts are administered by individual counties through their general plans, which set forth County objectives and policies for long-range development, and community plans which provide more detailed schemes for implementing general plans. (State Ex. 10, G.S. No. 8/27/84-1, pp. 40, 41)

2. The County of Hawaii's goals for energy under its General Plan are:

a. To strive towards energy self-sufficiency for Hawaii County; and

b. To establish the Big Island as a demonstration community for the development and use of natural energy resources.
(Written Testimony of Ilima Piianaia, p. 2)

3. The designation of the proposed Kilauea Middle East Rift GRS is consistent with and implements the County of Hawaii General Plan. (Written Testimony of Ilima Piianaia, p. 1-3)

4. Once the proposed subzone is designated, exploration can occur to determine whether a resource exists with careful controls placed upon geothermal activities via subsequent permitting processes to mitigate any potential adverse impacts which may result from these geothermal activities. (Written Testimony of Ilima Piianaia, p. 3-5; Written Testimony of Manabu Tagomori, p. 9; Written Testimony of Robert Chuck, G.S. No. 8/27/84-1, p. 26)

5. The BLNR finds that the proposed designation of the Kilauea Middle East Rift GRS is compatible with the General Plan and land use policies of the County of Hawaii.

H. Act 296, SLH 1983, Factors - Potential Economic Benefits to be Derived from Geothermal Development and Potential Related Industries

1. The State of Hawaii depends upon petroleum supplies for 91.4 percent of all the energy consumed in the State. The oil that Hawaii imports costs the State about $1.5 billion per year in funds which flow out of the State for this purchase. As a consequence of the high cost of imported fuel, electricity rates in Hawaii are among the highest in the nation. (CDUA No. HA-3/2/82-1463, BLNR Findings of Fact, 2/25/83, p. 4-43)

2. The Department of Planning and Economic Development believes that geothermal energy is the largest, near-term baseload electric energy potential for Hawaii. Large scale development of the geothermal resources on the Big Island is essential to the attainment of the State and County of Hawaii objectives of energy self-sufficiency. (CDUA No. HA 3/2/82-1463, BLNR Findings of Fact 2/25/1983, p. 4-43)

3. About 60 percent of the total energy produced on the Big Island is generated from fossil fuels such as industrial and diesel oils. Due to the uncertainties of the price and supply of fuel oil, HELCO is seeking to ultimately meet electrical system demands solely from renewable energy sources such as geothermal. To become energy self-sufficient, that is, not depending on fossil fuel, the County of Hawaii would need over 100 megawatts from alternative sources. (Testimony of A. Nakamura, Transcript Vol. IV, p. 127)

4. The current investigation regarding the feasibility of an interisland cable suggests that a substantially larger market, Oahu and the other islands, could be supplied by geothermal electrical generation in a time frame that is consistent with that required for exploration and resource evaluation on the Kilauea East Rift Zone. Based on industry statistics, exploration and resource evaluation may be estimated to take from one to three decades. This time frame is also consistent with projections of increasing demand for alternative energy supplies arising from an increase in constant dollar costs of fossil fuels anticipated to begin in about 1995. (Written Testimony of Donald Thomas, p. 3-4)

5. Development of geothermal resources would provide numerous but temporary job opportunities during the construction, maintenance, and operation of the roads, wells, and power generation facilities. The total number of employment opportunities will depend on specific development proposals. (Written Testimony of Manabu Tagomori, p. 18)

6. Based on the assumption of 25 project employees, direct wages may be about $560,000 annually, having a multiplier effect totalling an estimated $1.3 million. This would result in some impact on the state and county economy, but not a significant impact. A greater potential for permanent jobs for local residents may be provided by direct use applications of geothermal heat. (State Ex. 9, G.S. No. 8/27/84-1, p. 2)

7. Various sources of public revenue may result from a geothermal facility, including property tax, fuel tax, general excise tax, corporate income tax, personal income tax, and possibly royalty income. (State Ex. 9, G.S. No. 8/27/84-1, p. 4-6)

8. Direct use of geothermal heat should offer local residents many economic opportunities. The warm water effluent from a geothermal electric facility can provide an inexpensive source of process heat for various uses. (State Ex. 9, G.S. No. 8/27/84-1, p. 9)

9. Some agricultural activities which can be supported by geothermal heat include: sugarcane processing, drying and dehydration of fruits and fish, fruit and juice canning, production of livestock feed from fodder, freeze drying of food and coffee, aquaculture and fishmeal production, refrigeration and ice making, soil sterilization, and fruit sterilization by dipping in hot water. (Written Testimony of Manabu Tagomori, p. 183 and State Ex. 2; Written Testimony of Donald Thomas, p. 8; Testimony of Nelson Ho, Transcript Vol. IV, p. 199)

10. Industrial applications of direct geothermal heat may include extraction of potentially marketable minerals, such as silica or sulfur from geothermal fluids, production of cement building slabs, and production of liquid combustion fuels from biomass, e.g. bagasse or other agricultural by-products. (Written Testimony of Manabu Tagomori, p. 18 and State Ex. 2, p. 17)

11. Other direct uses include hot geothermal mineral water spas which have proved to be of major commercial value in producing tourist revenue in Japan, Europe, U.S.S.R., and mainland United States, where millions visit these facilities annually. In places where fresh water is scarce, geothermal heat can be used to distill fresh water from saline water. (Written Testimony of Manabu Tagomori, p. 18 and State Ex. 2, p. 17)

12. If the benefits of direct use applications are to be available in several areas, then small decentralized geothermal facilities

should be encouraged. Decentralized developments owned and operated by various developers may also promote competitive pricing for both electricity and process heat. With imaginative marketing, Big Island processed farm products can be sold world-wide. (State Ex. 2, p. 18)

13. The BLNR finds that there are great economic benefits to be derived by electrical and direct use of geothermal resources.

I. Act 296, SLH 1983, Factors - Compatibility of Geothermal Development and Potential Related Industries with the Uses Permitted under Sections 183-41 and 205-2, Hawaii Revised Statutes, Where the Area Falls Within a Conservation District

1. Conservation Districts include areas necessary for protecting watershed and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose èxisting openness, natural condition, or present state of use, if retained, would enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept. (State Testimony of Robert T. Chuck, G.S. No. 8/27/84-1, p. 28) (HRS §205-2)

2. Conservation means a practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural and scenic resources attendant to land including territorial waters within the State, to ensure optimum long-term benefits for the inhabitants of the State (Chapter 13-2-1, Hawaii Administraive Rules). (State Testimony of Robert T. Chuck, G.S. No. 8/27/84-1, p. 28)

3. Of the four land use districts, the Conservation District is the only one administered by the State of Hawaii. Individual counties administer urban, rural and agricultural lands. (State Ex. 10, G.S. No. 8/27/84-1, p. 39)

4. Chapter 183-41, HRS, established Conservation Districts and enabled the State Department of Land and Natural Resources to promulgate regulations to implement the statute. Implementation was accomplished under Title 13, Chapter 2, Hawaii Administrative Rules, DLNR. Under this rule, the Conservation District is further subdivided into five subzones: Protective (P), Limited (L), Resource (R), General (G) and Special Subzones (SS). (State Ex. 10, G.S. No. 8/27/84-1, p. 39)

5. The Protective Subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries; significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. The Limited Subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the Resource Subzone is to

develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General Subzones are open space areas where specific conservation uses may not be defined, but where urban use would be premature. Special Subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area. (State Ex. 10, G.S. No. 8/27/84-1, p. 39)

6. The great majority of the land within the proposed Kilauea Middle East Rift GRS is zoned Conservation-Protective. The extreme eastern and southeastern areas of this proposed GRS is classified agricultural under the jurisdiction of the County of Hawaii. (State Ex. 2, p. 42)

7. Act 296, SLH 1983 and as amended by Act 151, 1984, specifically states that "geothermal resource subzones may be designated within the urban, rural, agricultural, and conservation land use districts established under section 205-2, HRS.

8. Methods for assessing the compatibility of geothermal development within a conservation district are left to the discretion of the BLNR and may be based on currently available public information. However, subzoning itself does not automatically permit any geothermal development or convey any rights to individuals beyond application for the required permits to conduct geothermal activities in any of these designated areas. (State Ex. 2, pp. 1, 43)

9. In granting a Conservation District Use Permit (CDUA No. HA 3/2/82-1463) for geothermal exploration, the BLNR stated that "the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation lands involve multiple uses which range from absolute preservation to regulated uses...The range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restricted context." This balancing test may also be applied by the BLNR to conservation lands contained within the proposed Kilauea Middle East Rift GRS when subsequent permits are considered. (State Ex. 2, p. 43)

10. The BLNR finds that strict controls to mitigate potential impacts within the conservation district to protect valuable resources within this proposed subzone can be accomplished.

J. Act 296, SLH 1983, Factors - Objectives, Policies and Guidelines Set Forth in Part I of Chapter 205A, HRS

1. Chapter 205A, HRS, relating to Coastal Zone Management is not applicable to the designation of geothermal resource subzones at the Kilauea Middle East Rift, Island of Hawaii.

K. Act 296, Factors - Provisions of Chapter 226, HRS

1. Chapter 226, HRS, relating to the Hawaii State Planning Act and its more detailed Energy Functional Plan encourages energy self-sufficiency generally and the use and development of geothermal energy specifically. (Written Testimony of Manabu Tagomori, p. 2-4; State Ex. 14, p. 23, G.S. No. 8/27/84-1)

2. The BLNR finds that the designation of the proposed Kilauea Middle East Rift GRS complies with the provisions of Chapter 226, HRS.

L. Consideration and Examination of Factors for Recommending Subzone Designation

1. In enacting Act 296, SLH 1983, the Legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. (Act 296, SLH 1983, Section 1)

2. Pursuant to Act 296, SLH 1983, the BLNR compared all areas showing geothermal potential within each county and proposed geothermal resource subzones, based on a finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection b of Act 296. (HRS §205-5.2(a)(d))

3. The Technical Committee did conduct a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. (State Ex. 14, p. 63, G.S. No. 8/27/84-1)

4. There is only a very limited amount of land within the state suitable for subzone designation. Less than 1% of the state's total land area has been designated or proposed as a geothermal resource subzone. (Written Testimony of Manabu Tagomori, p. 8)

5. Examination of the factors set forth in §205-5.2(b), HRS, indicates that several impacts may result from the exploration, development, and production of geothermal resources for electrical power generation; however, these impacts can be mitigated. All of these factors have been cumulatively examined and it has been determined that the Kilauea Middle East Rift Geothermal Resource Subzone can provide an acceptable balance among these factors as required by Act 296, SLH 1983. (State Ex. 14, G.S. No. 8/27/84-1, p. 63)

6. Act 296, SLH 1983, as amended by Act 151, SLH 1984, provides that exploration, development or production of electrical energy from geothermal resources is to be restricted to areas designated as geothermal resource subzones.

7. It cannot be guaranteed that land areas designated as subzones will provide any certain amount of geothermal capacity. This is clearly demonstrated by the fact that several Hawaii geothermal exploration wells have not proven to be productive. (Written Testimony of Manabu Tagomori, p. 8)

8. The subzoning process is a broad land-use designation. Subzoning does not authorize geothermal activities. (Written Testimony of Manabu Tagomori, p. 8)

9. All geothermal activities require State or County development permits. At that time, a proposal for specific geothermal development can be accepted, rejected, or modified to assure development only in an environmentally acceptable manner. (State Ex. 5)

10. Buffer zones have been used throughout the subzoning process to minimize any potential environmental impacts to the National Park and surrounding areas. (Written Testimony of Manabu Tagomori, p. 9)

11. Directional drilling technology can tap geothermal resources at depth while causing minimal disturbance to surface areas directly above. If isolated patches of land within a subzone are not subzoned, this will prevent the use of directional drilling below the area not subzoned, as the subzone boundary will extend in a straight line below the surface as shown on the attached diagram. (Written Testimony of Manabu Tagomori, p. 9)

12. The Kilauea Middle East Rift Zone has been found to have the following desirable elements for the exploration, development and production of geothermal resource energy:

a. The Kilauea Middle East Rift Zone has potential for developing geothermal resources. (State Ex. 14, G.S. No. 8/27/84-1, p. 64)

b. There is interest in the exploration, development and production of geothermal resource energy in the Kilauea Middle East Rift Zone. (State Ex. 14, G.S. No. 8/27/84-1, p. 64)

c. There is a commitment towards geothermal resource energy as a viable alternate energy source for Hawaii. (State Ex. 14, G.S. No. 8/27/84-1, p. 64)

d. Advanced technology in geothermal resource development, such as emission control systems, noise control systems, well and power plant designs, and safety provisions from lava flows, will reduce the concerns for public health and safety. (State Ex. 14, G.S. No. 8/27/84-1, p. 64)

e. Potential environmental impacts have been fully investigated and it has been determined that these impacts can be mitigated to acceptable levels. (State Ex. 14, G.S. No. 8/27/84-1, p. 64)

13. After having considered and examined all factors, the Board of Land and Natural Resources hereby determines that the Kilauea Middle East Rift Zone be designated as a geothermal resource subzone, and the boundaries defined as follows (Written Testimony of Manabu Tagomori, p. 19-20):

a. The eastern boundary abuts the existing Kamaili GRS, straddling the 90% probability band and forming a contiguous land use designation. The Board, in the Decision and Order had directed the Division to assess the Kilauea Middle East Rift Zone beginning on the western boundary of the Kamaili GRS.

b. The southern boundary closely parallels the 90% probability line and is limited because the resource potential of areas to the south of 90% probability line is believed to diminish with distance from the rift zone. Also, permeability in areas south of the rift zone is expected to be low as a result of mineral deposition from salt water intrusion. Potential hazards from lava flows are greater south of the rift zone due to the southward sloping contour of the land. Also, earthquakes are relatively more frequent south of the rift zone.

c. The western boundary was determined assuming that Kahaualea is designated as a natural area reserve. The boundary provides a 2000-foot buffer between the GRS and Kahaualea to mitigate any possible effects on the prime native forest and wildlife at Kahaualea.

d. The northern GRS boundary was determined a reasonable distance north of the rift zone to provide for areas less susceptible to lava flow hazards. It is anticipated that power plants may be sited on locally elevated ground in these safer northern areas.

II. CONCLUSIONS OF LAW

Based upon the Findings of Fact aforesaid, the BLNR concludes as follows:

1. The Board of Land and Natural Resources is authorized pursuant to Act 296, SLH 1983, and Act 151, SLH 1984, and Chapter 184, Title 13, Hawaii Administrative Rules of the DLNR, to designate geothermal resource subzones. (HRS §205-5.1(b))

2. In its assessment of the Kilauea Middle East Rift Zone as a potential geothermal resource subzone, the BLNR has fully examined and considered the following factors:

a. The area's potential for the production of geothermal energy;

b. The prospects for the utilization of geothermal energy in the area;

c. The geologic hazards that potential geothermal projects would encounter;

d. Social and environmental impacts;

e. The compatibility of geothermal development and potential related industries with present use of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

f. The potential economic benefits to be derived from geothermal development and potential related industries;

g. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district; and

h. The objectives, policies and guidelines set forth in Part I of Chapter 205A, and the provisions of Chapter 226, HRS, the Hawaii State Planning Act, and also, the Hawaii State Energy Functional Plan.

3. There exists a future need for geothermal energy as an alternate source of energy on the Island of Hawaii and throughout the State of Hawaii.

4. Kilauea Middle East Rift Zone has high potential for geothermal energy resource development

5. There exists substantial private developer interest in the exploration and development of geothermal resource energy in the Kilauea Middle East Rift Zone.

6. Any adverse impacts relating to geologic hazards, social and environmental impacts, and compatibility with conservation districts, county land use policies, and the State Plan, which may result as a consequence of geothermal development, can be effectively mitigated through subsequent permitting processes.

7. The BLNR finds that the Kilauea Middle East Rift Zone as proposed for designation as a geothermal resource subzone demonstrates an acceptable balance between the factors set forth in HRS §205-5.2(b).

8. In its designation of the Kilauea Middle East Rift Zone as a geothermal resource subzone, the BLNR has fully considered and balanced the exploration and development of Hawaii's geothermal resources with the interests in preserving Hawaii's unique social and natural environments.

9. The provisions of Act 296, SLH 1983, Act 151, SLH 1984, and Title 13, Chapter 184, Hawaii Administrative Rules of the DLNR have been fully complied with in the designation of the Kilauea Middle East Rift Zone as a geothermal resource subzone.

III. DECISION AND ORDER

Based on the Findings of Fact and Conclusions of Law stated herein, IT IS THE DECISION of the Board of Land and Natural Resources to designate the Kilauea Middle East Rift Zone, containing an area of approximately 11,745 acres, described herein, on the map marked "Figure 1" attached hereto and made a part hereof, as a Geothermal Resource Subzone.

DATED: Honolulu, Hawaii, ______________________________.

BOARD OF LAND
AND NATURAL RESOURCES

____
SUSUMU ONO
Chairperson and Member

____
MOSES W. KEALOHA
Member-at-Large

____
J. DOUGLAS ING
Member

____
ROLAND H. HIGASHI
Member

____
JOHN Y. ARISUMI
Member

____
LEONARD H. ZALOPANY
Member

APPROVED AS TO FORM:

____
WILLIAM M. TAM
Deputy Attorney General
State of Hawaii
Attorney for BOARD OF LAND
AND NATURAL RESOURCES

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Proposed Findings of Fact, Conclusions of Law and Decision of the Division of Water and Land Development, Department of Land and Natural Resources, State of Hawaii, was served by mail, postage prepaid, upon the following parties:

- Benjamin Matsubara and Stephanie Rezents, attorneys
  1717 Pacific Tower, 1001 Bishop Street, Honolulu, Hawaii 96813
  Representing: - Estate of James Campbell (intervenor-applicant)
  - True/Mid-Pacific Geothermal Venture (intervenor-applicant)

- Patricia O'Toole, Deputy Corporation Counsel
  25 Aupuni Street, Hilo, Hawaii 96720
  Representing: County of Hawaii; Planning Department

- Wendell Y. Y. Ing, attorney
  (Ken Kupchak, co-counsel)
  209 Kinoole Street, Room 8, Hilo, Hawaii 96720
  Representing: - Susan Carey (party)
  - Diane Ley (party)
  - Volcano Community Association (party)
  - Lehua Lopez (party)
  - Eva Lee (party)
  - Louis Whiteaker (party)
  - Chiu Leong (party)
  - Virginia B. MacDonald (party)
  - Debra Hopson (party)
  - Ann Markham (party)
  - Mike Markham (party)
  - Beverly MacCallum (party)
  - Matt Luera (party)
  - Hawaii Audubon Society (party)
  - Sierra Club, Hawaii Chapter (party)

- Mae Evelyn Mull (party - representing herself)
  P.O. Box 275, Volcano, Hawaii 96785

- Frederick Warshauer (party - representing himself)
  P.O. Box 192, Volcano, Hawaii 96785

- Karl & Melissa Kirkendall (party)
  P.O. Box 428, Pahoa, Hawaii 96778

- John L. Perreira (party)
  212 Punahele St., Hilo, Hawaii 96720

o Thomas E. Luebben, Attorney
Luebben, Hughes, Tomita and Borg
201 Broadway S.E.
Albuquerque, New Mexico 87102
Representing: - Palikapu Dedman (intervenor-applicant)
- Emmett Aluli (Intervenor-applicant)

DATED: Honolulu, Hawaii, December 4, 1985.

Dona L. Hanaike

DONA HANAIKE
EDWIN P. WATSON
Deputy Attorneys General
State of Hawaii
Attorneys for DIVISION OF
WATER & LAND DEVELOPMENT,
DEPARTMENT OF LAND & NATURAL
RESOURCES

RECEIVED

BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

'84 DEC 7 P 1:47

In the Matter of the Designation of Kahaualea, Puna, Hawaii as a Geothermal Subzone.) G.S. NO. 8/27/84-1

NATURAL RESOURCES
STATE OF HAWAII

TESTIMONY FOR THE
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
ON THE PROPOSAL OF
THE UPPER KILAUEA EAST RIFT ZONE
AS A GEOTHERMAL RESOURCE SUBZONE

I. INTRODUCTION

A. Background/Qualifications of Robert T. Chuck

Mr. Chairman, Members of the Board, my name is Robert T. Chuck, and I will be making the Department of Land and Natural Resources' presentation on the designation of the Upper Kilauea Rift Zone as a Geothermal Resource Subzone. I am the Manager and Chief Engineer for the Department's Division of Water and Land Development, the division responsible for recommendations on the designation of areas as geothermal resource subzones.

I am a registered professional engineer in the State of Hawaii in the Civil, Structural and Hydraulic branches. I have been an instructor at the University of Hawaii for over 25 years and have served as Manager and Chief Engineer of the Division of Water and Land Development since its inception in 1960.

In managing this Division I have developed programs for the planning and development of water projects and the regulation, management and protection of Hawaii's water and mineral resources.

This division, under my direct supervision, monitors and regulates all exploratory drilling for water and geothermal resources. The direct regulation and monitoring of geothermal well drilling as well as the maintenance of an up-to-date inventory of mineral resources and mining activities in the State is accomplished under the division's Mineral Resources Program. My division staff consisting of civil engineers, hydrologists, geologists, energy specialists and resource planners bring considerable expertise to the task of designating geothermal resource subzones.

B. Presentation Approach

My presentation today is intended to focus on and explain the legislative and departmental objectives in designating geothermal resource subzones, the approach utilized and the factors considered in the assessment of geothermal resource areas, with SPECIAL reference to those utilized in the evaluation of the proposed Upper Kilauea East Rift Zone.

II. LEGISLATIVE INTENT IN DIRECTING THE BOARD OF LAND AND NATURAL RESOURCES TO DESIGNATE GEOTHERMAL RESOURCE SUBZONES.

Quite clearly, as stated in Act 296, the Legislative intent, in directing the Board of Land and Natural Resources to designate geothermal resource subzones, was to assure that the interest in developing geothermal resources would be balanced with the interest in preserving Hawaii's unique social and natural environment.

The Act directs the Board to designate geothermal resource subzones only after having assessed seven factors or criteria using currently available public information. The criteria include potential for production, prospects for utilization, presence of geologic hazards, social and environmental impacts, land use compatibility, potential economic benefits and compatibility with land use zoning.

As stated in Act 296 the Legislature intended that the Board select only those areas that can best demonstrate an <u>acceptable</u> balance among the criteria set forth in the Act.

It is our belief that the proposal of the Board follows the Legislature's intent.

III. OBJECTIVE OF THE BOARD OF LAND AND NATURAL RESOURCES

A. The BLNR is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii under authority of Act 296, SLH 1983 and Act 151, SLH 1984. Once subzones are established, geothermal exploration, development and production of electrical energy will be limited to only these designated areas.

B. To the extent provided by Act 296 and Act 151, all existing statutes, ordinances and rules are to be respected and are not superseded by this effort.

C. The State of Hawaii was assessed for geothermal resource potential on a county-by-county basis. Currently available public information was utilized in the statewide assessment as provided by Act 296, SLH 1983. The various studies and existing information were examined and incorporated into technical reports and were made available to the general public upon request. The data was analyzed and reports prepared through a consorted staff effort under the direct supervision of Mr. Robert T. Chuck, Manager-Chief Engineer, Div. of Water and Land Development.

IV. Act 296, SLH 1983 (Exhibit No. 1-A)

A. Highlights of Act 296, SLH 1983, signed into law June 14, 1983.

1. Amends Chap. 205 - Land Use Commission.
2. Provides for designation in Conservation, Agriculture, Urban, and Rural.
3. Geothermal Resource exploration, development and production is limited to only the designated areas.
4. The Board of Land and Natural Resources is responsible for designating geothermal resource subzones.
5. The BLNR shall adopt administrative rules (Chap. 184).

6. The administration of subzones shall be governed as follows:

   BLNR for conservation districts

   State and County laws for Agricultural

   Urban and Rural Districts

7. No land Use Commission approval needed for use of subzones.

8. Provides for contested case hearing, upon request, before the BLNR or County agency prior to issuance of a geothermal resource permit.

9. The BLNR shall conduct a county-by-county assessment of potential geothermal resource areas and shall be revised or updated at the discretion of the BLNR once every 5 years beginning in 1988.

10. An EIS is not required for the assessment.

11. The assessment shall examine factors to include but not be limited to: (Exhibit No. 1-B)

    * Potential geothermal energy production
    * Use of geothermal energy in the area
    * Geologic Hazards
    * Social and Environmental Impacts
    * Compatibility with present and planned use
    * Potential economic benefits
    * Compatibility with conservation principles where a subzone falls within a conservation district.

12. This assessment may be based on currently available public information.

13. Any property owner may petition the BLNR to have an area designated as a geothermal resource subzone.

14. The BLNR shall propose potential areas for designation based upon assessment factors and hold public hearings in close proximity to the proposed area. The hearings shall be held before the Board and not be conducted by any agent or representative.

15. At the close of the hearing, the BLNR may designate the subzones. Upon request, the BLNR shall issue its findings and principal reasons for its decision.

16. Designated areas may be withdrawn by the BLNR.

17. The Act shall not apply to active exploration, development, or production of electrical energy taking place on the effective date of the Act. Expansion of such activities however are subject to the provisions of the Act.

V. Act 151, SLH 1984 (Exhibit No. 1-C)

A. Highlights of Act 151, SLH 1984, signed into law on May 25, 1984. This Act clarifies some of the provisions of Act 296, SLH 1983 as follows:

1. Permits geothermal development activities within urban, rural, agricultural, and conservation land use districts.

2. Defines geothermal development as "the exploration, development or production of electrical energy from geothermal resources."

3. Existing leases within an agricultural district which were issued a special use permit by the County for geothermal development activities, is declared a geothermal resource subzone for the duration of the lease. (Exhibit No. 3).

4. Clarifies the governing jurisdiction of the State and County governments in the geothermal development approval process, and also exempts the permit process from special use permit procedures under section 205-6.

5. Clarifies the issuing County agency by defining "appropriate county authority" as the "county planning commission unless some other agency or body is designated by ordinance of the county council."

6. Further clarifies the roles of the State and County governments in connection with land use designations, as well as conduct of a permit approval process.

7. Mandates that the county authority, in the absence of a mutually agreed upon extension, must provide a decision on a complete and properly filed application within 6 months.

8. The BLNR shall make its determination regarding the subzone designation of all or any portion of the area described in the BLNR decision and order, dated Feb. 25, 1983, which was the subject of a conservation district use permit on or before December 31, 1984.

VI. STUDY APPROACH (Exhibit No. 4)

A. Statewide Geothermal Resource Assessment

1. Selection of a Geothermal Resource Technical Committee by the Dept. of Land and Natural Resources.

2. Technical Committee members were selected on the basis of their specific expertise in the fields of Engineering, Geochemistry, Reservoir Engineering, Geology, Geophysics and Hydrology. (Exhibit No. 1-D)

MANABU TAGOMORI, P.E. (Chairman)
Engineer
Dept. of Land & Natural Resources
State of Hawaii

BILL CHEN, PH. D.
Engineer
Dept. of Computer Service
University of Hawaii - Hilo

DALLAS JACKSON
Geophysicist
Hawaiian Volcano Observatory
U.S. Geological Survey

JAMES KAUAHIKAUA, Ph.D.
Geophysicist
U.S. Geological Survey
Honolulu, Hawaii

DONALD THOMAS, PH.D. (Tech. Leader)
Geochemist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

DANIEL LUM
Geologist
Dept. of Land & Natural Resources
State of Hawaii

RICHARD MOORE, PH.D.
Geologist
Hawaiian Volcano Observatory
U.S. Geological Survey

JOHN SINTON, Ph.D.
Geologist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

3. This phase focused upon available public geotechnical information, its interpretation and analysis of potential geothermal resources throughout the State. (Exhibit No. 5)

4. The Dept. of Land and Natural Resources issued a Public Notice requesting for Geothermal Resource Information in an effort to maximize the base of available data pertinent to its evaluation of the criteria set forth in Act 296, SLH 1983. This public notice was published in the Star Bulletin on April 16, 18, 1984.

5. The committee's assessment was based on the following types of data:

   * Ground Water Temperature. Near surface water having temperature significantly above ambient, indicative of a possible nearby geothermal reservoir.

   * Geologic Age. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles can infer geothermal resources and focus exploration to a broad area.

   * Geochemistry. Ground water having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered ground water are anomalously high silica (SiO_2), chloride (Cl) and magnesium (Mg) concentrations. In addition, the evidence of above normal concentrations of trace and volatile elements such as mercury (Hg) and radon (Rn) may indicate leakage of geothermal fluids into nearby rock structures.

* Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of circulating ground water. Therefore, anomalously low resistivity may indicate warm saline ground water associated with geothermal resource.
* Infrared Surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above ambient ground temperatures which may be indicative of a nearby geothermal resource..
* Seismic Studies. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.
* Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Rocks at high temperature or those that have been thermally altered, are represented by magnetic lows which are useful in locating the hottest parts of a rift zone.
* Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones. Interpretation of the variation in rock density integrated with other geologic studies can be useful in confirming the location of a geothermal resource.
* Exploratory Drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.
* Self-Potential Data. Self-potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea east rift. Self-potential anomalies may reflect hot water flowing through a permeable vertical facture connected to a broad heat source at depth.

A more in-depth description of the various types of geothermal exploration techniques can be referred to in the earlier DLNR report titled, "Assessment of Available Information Relating to Geothermal Resources in Hawaii", Circular C-98.

6. The Technical Committee assessed the State of Hawaii on a county-by-county basis shown on the Map (Exhibit No. 2-A) and identified seven High Temperature Potential Geothermal Resource Areas listed below: (Exhibit No. 1-E)
   * Haleakala S.W. Rift Zone, Maui
   * Haleakala East Rift Zone, Maui
   * Hualalai, Hawaii
   * Mauna Loa S.W. Rift Zone, Hawaii
   * Mauna Loa N.E. Rift Zone, Hawaii
   * Kilauea S.W. Rift Zone, Hawaii
   * Kilauea East Rift Zone, Hawaii
7. The selection of these high temperature resource areas were based on the potential for production of electrical energy. The consensus of the Technical Committee was that present day technology requires a geothermal resource to have a temperature greater than 125°C (257°F) at a depth of less than 3 km.
   (Exhibit No. 6, Circular C-103, "Statewide Geothermal Resource Assessment")

B. Public Participation and Information Meetings

1. A series of public informational meetings were conducted on the islands of Maui and Hawaii. The objective of these meetings were to open lines of communication between the public and the Dept. of Land and Natural Resources. (Exhibit No. 7, Circular C-99, "Public Participation and Information Program for Designating Geothermal Resource Subzones").

2. The first series of meetings were to report the most likely locations of geothermal resources. The second series focused on the identification of impact issues.

3. Throughout the process, from the enactment of Act 296, to the Proposed for Designating Geothermal Resources Subzones by the BLNR, public comments and participation have been invited from various interested parties to assist the Department and the Board.

4. To ensure full public participation, the time, place and purpose of these meetings were announced in newspaper publications, radio announcements and letter invitations.

5. The following are dates and places of these meetings:

May 8, 1984	Hilo, Hawaii
May 9, 1984	Kahului, Maui
May 29, 1984	Hilo, Hawaii
May 30, 1983	Kahului, Maui
July 10, 1984	Pahoa Community Council
July 11, 1984	Volcano Community Association

C. Examination of the seven selected high temperature resource areas relative to social, economic, environmental, geologic-hazards and compatibility with land uses. (Exhibit No. 1-F)

1. Also considered in the evaluation of impacts were the provisions of Chap. 226, the Hawaii State Planning Act and the objectives, policies and guidelines set forth in Part I of Chap. 205A Coastal Zone Management, if applicable. (Exhibit No. 1-G)

2. Methods for assessing the factors outlined in Act 296, shall be left to the discretion of the Board and may be based on currently available public information.

3. The Board shall propose areas for potential designation which best demonstrate an acceptable balance between the factors set forth in Act 296.

4. The following factors and/or concerns were reviewed and evaluated by a joint-staff assessment group:

Social Impacts. Social impacts related to geothermal development may include health and noise aspects, impacts to lifestyle, culture and community setting, as well as aesthetic aspects.

a. Health Aspects. The health aspects of geothermal resource development involve primarily the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds.

b. Noise Aspects. Although noise levels associated with geothermal energy development and operation are comparable with with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor to be controlled and monitored. In May of 1981, the County of Hawaii Planning Department issued a set of Geothermal Noise Level Guidelines to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. The County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with. It is expected that the County of Maui will adopt similar noise guidelines for geothermal activities.

c. Lifestyle, Culture and Community Setting. The lifestyle, culture and community setting or atmosphere of an area are very much inter-related and represent a major concern in terms of the effects of any introduced changes, especially when the changes may be in the direction of industrial development in a relatively rural setting.

d. Aesthetic Aspects. Although in some areas with potential geothermal resource development the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping. Visual impacts can be further minimized by adjusting the location of the site, the alignment of structures so as to present the smallest possible aspect and by blending structures with surroundings by painting appropriately and by use of non-reflective, light absorbent materials and textures and by shielding facilities from view by locating behind a puu, or hill, or by placement in a forested area. Impacts can be further minimized by use of buffer zones surrounding geothermal facilities.

(Exhibit No. 8, Circular C-104, "Social Impact Analysis of Potential Geothermal Resource Areas".)

Economic Impacts. As with any ecoomic activity, the injection of dollars into the economy will result in direct impacts through the purchases of various goods and services from the other industries.. In the case of a 20 to 30 megawatt geothermal plant, the dollars injected into the economy may be the result of the inflow of investment capital or the dollars prevented from being "exported" from the State or the County in the substitution or displacement of approximately 390 thousand barrels of petroleum each year that would have otherwise been imported into this State for conversion into electricity. The additional purchases made will, in turn, cause these industries to purchase more goods and services from other industries. The result is a chain-reaction of purchases, or a "multiplier" effect produced by the original increase in purchase.

These impacts are long run in nature. That is, the subsequent indirect and induced activities do not take place instantaneously, but require fairly lengthy periods of time for such events to take place, all other things held constant.

The overall assessment is that a 20 to 30 megawatt geothermal power plant will have some economic impact on a State-wide and County-wide basis, but the impact would probably not be significant.

Public Sector and Community Resource Analysis. Any economic activity results in certain gains and losses to the economy. In particular, an economic activity provides the public sector with additional sources of revenues and also increases the burden on the available public resources. In order to assess the impact of this project, an estimate of the incremental revenues and costs needs to be made. For the purposes of this analysis, only those major financial impacts likely to occur as a result of this project was considered. Order-of-magnitude estimates of the variables in this section were made where data was available and considered applicable to the assumed 20 to 30 megawatt geothermal plant case study.

a. Public Sector Revenue. At the County level, three major sources of revenue was addressed in relation to the existence of a geothermal plant. The first is property taxes, followed by fuel taxes and sewer charges. At the State level, there are four major sources of public revenue that deserves treatment. The first is the general excise tax. Next, is income taxes, both the corporate and the personal. Finally, the royalty income on the geothermal mineral rights.

b. Community Resource Analysis. Although the on-site facility will draw upon the community's resources, this section addressed only the probable impacts that may take place due to the increase in population within the immediate community or to the County. The principal resources that will be analyzed includes: housing, lower education, police and fire.

Based upon the scenerio that all 25 workers are from outside the County, the selected sources of revenues to both the County and to the State will not be a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, a more precise delineation of the type of plant, in terms of legal organization and activities, will be required to determine a more accurate public revenue estimate.

Overall, the impact of the 25 additional households to the community will be primarily in the housing market, if all 25 workers are from outside the County. The likelihood of this "worst case" assumption seems to be fairly small. Thus, it is probable that a part of the needed workforce will come from the County and therefore the housing impact will not be as great. Other community resources will not be affected in a significant manner under the current scenerio.

(Exhibit No. 9, Circular C-105, Economic Impact Analysis of Potential Geothermal Resource Areas".)

Environmental Impacts.

a. Meteorology. Climatological factors important in assessing environmental impact of geothermal development include winds, rainfall, air temperature, as well as tradewind temperature inversions and ground temperature inversions. The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise. The most common winds over the Hawaiian Islands are the trade winds from the northeast which account for about 70% of the winds in the Islands. These trades prevail over 90% of the time in June through August and only 40 to 60% of the time in January through March. During the winter, the trade winds are sometimes absent almost an entire month. The variability of rainfall within a resource area can affect the presence of naturally occurring or emitted suspended particulates.

b. Flora and Fauna. One of the more serious potential impacts of geothermal development is the disruption of native forests. Native forests are partiularly vulnerable to invasion by exotic species along roadways and in cleared areas. Once the invasion begins, the native forest is gradually altered as non-native species multiply and spread.

Major geothermal development, with an attendant network of roads and construction corridors maybe expected to dissect and possibly degrade undisturbed native forest by opening it to invasion by weedly species. Siting of geothermal development to avoid biologically valuable forest can mitigate potential impacts.

Of Hawaii's seven plant species which are formally listed as endangered, only one, the Hawaiian vetch (*Vicia menziesii*) is found within the resource areas. However, Hawaii has numerous rare plants, over 800 of which have been proposed for listing as endangered. Undoubtedly many of these candidate species may be found within the resource areas. For example, the endemic Hawaiian fern, (Adenophorus periens), is known to be present in the Kahauale'a section of the Kilauea East Rift Zone. Protection of rare plant species will have to be undertaken on a project-by-project basis, where botanical surveys of specific areas being considered for development are possible.

The impact of geothermal development on native forest birds focused on the value of the forest for native bird habitat. Most native birds share habitat to some degree, and it is this characteristic which permits use of the existence of endangered bird habitat as an index of overall native bird habitat value.

Endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are considered to be the most authoritative estimate of the actual habitat for a particular endangered species.

Geothermal development may have potential negative impacts such as construction noise and human activity which favor urban nuisance species over native forest species. It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal development. Any development within the habitat of native birds which have potential environmental impact should be fully investigated and mitigation measures implemented.

Rare invertebrates known to exist in the resource areas include scientifically important fruit flies (giant

Drosophila spp), tree snails (Partulina spp), and special care-adapted fauna residing in lava tubes. Tree and land snails, many of which, like other Hawaiian invertebrates, are found nowhere else in the world, are associated primarily with native forest and probably exist in all resource areas. Impacts to these species can be largely avoided by not siting geothermal development in native forest areas.

c. Surface Water. While the drilling and construction phases of geothermal development could result in degradation of surface waters, little if any impact is expected since there are no perennial streams located in the geothermal resource areas considered.

Almost all geothermal fluids contain dissolved solids greater than 1000 ppm, and their indiscriminate dischage into streams, ponds, and watersheds should not be allowed, therefore the normal practice is to reinject geothermal fluids.

d. Ground Water. Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water.

Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations.

Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes water is held between the dikes to a height of more than 2,000 feet above sea level.

Basal water occurs most commonly in the islands. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. In the areas considered, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the ground water aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions.

e. Air Quality. Assessment of air quality impacts resulting from geothermal development requires examination of ambient air quality in geothermal rift zones, emissions from geothermal wells and power plants, and the current level of geothermal emission abatement technology.

Ambient Air Quality. The chemical composition of gases varies with the location of the geothermal reservoir; however, the major constituent is typically carbon dioxide, and significant amounts of methane and hydrogen sulfide with trace amounts of benzene, radon and mercury. It should be noted that gases from igneous-related geothermal resources such as Kilauea East Rift Zone typically have much lower quantities of benzene or none at all.

Quantification of pre-development concentrations of naturally occurring emissions in geothermal rift zones is essential in order to assess any future changes in emission concentrations resulting from development of the geothermal resource.

Quantification was undertaken by the State Department of Planning and Economic Development in a two-year environmental baseline survey of the Kilauea East Rift Zone. Volume 1 of the survey report covers the period between December 1982 and December 1983. A second-year progress report for the perid between January 1, 1984 and May 31, 1984 is also available. (Referenced in Exhibit 10).

The principal parameters measured in this study include atmospheric concentrations of particulate material, sulfur dioxide gas, hydrogen sulfide gas, chlorine gas, carbon monoxide gas, elemental mercury vapor, radon, elemental and organic content of particulate material, rainwater pH, elemental and anionic content of rainwater, and wind speed and directions.

Baseline ambient levels are summarized as follows:

Particulate Matter. Total suspended particulate levels on the Rift Zone are extremely low. Sea salt aerosol, road and soil dust, volcanic emissions, diesel exhaust and organic material (pollen, spores, vegetative fragments and smoke particles) were found to be the principal sources of suspended particulates.

Sulfur Dioxide Gas. Sulfur dioxide concentrations due to volcanic activity can exceed stand and values, values for urban areas and human health and plant values for days at a time. In the absence of volcanic activity sulfur dioxide values are low.

Hydrogen Sulfide Gas and Chlorine Gas levels are very low and well below biological impact levels.

Occasional short term episodes of modest concentrations were observed but lasted less than a day.

Ambient mercury and radon values measured were more or less typical of atmospheric values nationwide. Higher values for radon were noted at the monitoring site closest to the current eruption during the study.

Proposed State Air Quality Standards for Geothermal Development. The State Department of Health has drafted revisions to its Administrative Rules Chapter 11-59, Ambient Air Quality Standards and Chapter 11-60, Air Pollution Control, covering geothermal activities (Referenced in Exhibit 10).

Proposed revisions to Chapter 11-59-4 specify ambient air concentrations of carbon monoxide, nitrogen dioxide, suspended particulate matter, ozone, sulfur dioxide, lead and hydrogen sulfide.

Emissions from Geothermal Development and Abatement. Environmental risks are due primarily to atmospheric emissions of noncondensing gases from the development and operation of geothermal wells and power plants. Hydrogen sulfide, and particulate sulfate from the atmospheric oxidation of hydrogen sulfide, benzene, mercury and radon are considered to be the more significant noncondensing gases from a health standpoint.

Exposure to atmospheric concentrations of hydrogen sulfide, benzene, radon, and mercury pose potential hazards to public as well as occupational health. In addition, exposure to hydrogen sulfide and toxic chemicals contained in abatement systems also pose an occupational health hazard.

The recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the noncondensable gases.

Use of this system would enable facilities to comply with the proposed State Department of Health air quality standard for geothermal developments since this standard required 98% of the H_2S present to be removed. (Exhibit No. 11)

As noted in Exhibit 11, Geothermal Technology, given the characteristics of the HGP-A reservoir fluids and the available emission abatement technology which would be required to comply with proposed State air quality standards, geothermal facility cooling tower emissions should not be toxic and the plume should consist entirely of water vapor. Brine from the plant will be injected back into the geothermal reservoir.

f. Historic and Archaeological Values. Historical values refer to the range of historical activities carried out by early Hawaiian residents. Archaeological values refer to all structures and artifacts that provide evidence of early habitation.

Evidence of these activities found in remaining archaeological sites is critical to reconstructing Hawaiian history and pre-history.

Geothermal development runs the risk of destroying such remaining evidence by site clearing and facility construction. Geothermal facility siting will be adjusted to avoid endangered plants and significant archaeological or historical sites. Impacts will be further minimized by use of buffer zones surrounding geothermal facilities.

g. Scenic and Aesthetic Values. Scenic and aesthetic values, in general, refer to landscape qualities likely to be impacted by geothermal development. Since most geothermal resource rift zones are located in remote wilderness areas, some of which are heavily forested, development of geothermal facilities can represent a visual intrusion. The preservation of natural beauty and aesthetics can be achieved by well-planned siting, landscaping, well-designed plant architecture, and proper mitigation measures.

(Exhibit No. 10, Circular C-106, "Environmental Impact Analysis of Potential Geothermal Resource Areas")

Geologic Hazards

a. Lava Flows. Lava flows vary in their flow behavior. Thick distal aa flows tend to bulldize, crush, bury, and burn any surface structures in their path. The more fluid, newly erupted, proximal (near-vent) lava tends to flow around obstacles. A fluid flow could enter buildings and may not cause much structural damage beyond igniting flammable materials and softening and distorting some of the metal work. In principle, fluid pahoehoe lava can subsequently be removed and the building reoccupied. In principle this would also apply to flows covering protective well cellars and thin pahoehoe flows surrounding transmission piping. However, recovery from a deep or long duration flow could take many months.

b. Pyroclastic Fallout. Explosive high-output eruption fountains may eject rock fragments of many types and sizes. The fallout range can be appreciable as far as 500 or 1000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones and may be tens or hundreds of feet thick.

Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent.

The probability of an eruption being potentially explosive (with resultant increased debris) increases as the coast is approached and is near 100% for a vent within about 1 kilometer of the coast. Steam from the near-surface water table promotes such explosiveness. Other dangers from fallout include lung irritation, poor visibility, anxiety or panic, blockage of escape routes, and severe cleanup problems.

c. Ground Cracks. Cracks which may open as much as several feet, can be the surface expression of dikes that fail to reach the surface. These cracks can produce a surface graben in which the ground subsides between two parallel cracks. This type of cracking related to magma movement is concentrated in volcanic rift zones which are narrow and clearly defined. Cracks could possibly open outside a rift zone; however, not enough information is available to assess the probability, which is considered to be low.

Ground cracking can also be associated with tectonic earthquakes. Their formation is often accompanied by a relative vertical or lateral displacement of the ground on either side. Tectonic ground cracking is usually localized in definable zones.

Ground cracking across a geothermal plant could cause a suspension of operation, depending on the extent and location of damages.

Pipes carrying steam between the wells and plant are unlikely to be damaged by minor ground cracking, since they are designed with expansion joints at regular intervals.

Ground cracking close to a well bore might open up an alternate path for the steam and cause its loss from the well. This is unlikely due to the vertical pitch of most cracks. However, in the event a crack does intercept a well bore several things might happen. If the cracks is below the local water table, water could rush into the bore and seal the release of steam by hydrostatic pressure. If the crack is above the water table, stream could escape into the surrounding rock strata. If the crack is close to surface, steam could escape and vent its way to the surface. In the latter event, a cement plug poured from an intercepting directional drill hole may seal the leak.

d. Ground Subsidence. Subsidence from geothermal fluid withdrawal is not likely to be a problem; since the islands are generally comprised of dense, permeable, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which usually occurs on or about active rift zones, e.g. Kilauea.

Small to large grabens may result from the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks.

Subsidence and cracking may also be associated with tectonic earthquakes, e.g. subsiding slump blocks along the Hilina fault system near Kilauea.

Collapsing pit craters and lava tubes can result in very severe localized subsidence. Pit craters usually occur within a summit or rift zone of a volcano. Fragile, near-surface lava tubes (usually found in pahoehoe flows) are subject to collapse from heavy surface activity. A geologic site-survey could identify these hazards.

Aside from the immediate effects subsidence may have on the foundation and contents of a power plant, subsidence also increases the hazards from lava flows since flows usually seek lower areas.

e. Earthquakes. Most earthquakes in Hawaii are volcanic in nature, resulting from the vibration of near surface magma movements. They usually cause little direct damage. Larger earthquakes tend to be tectonic, generally resulting from the movement of large rock bodies.

Major earthquake shaking can potentially damage poorly constructed buildings. Indirect damage may also be caused by smaller, more common volcanic earthquakes. Experts have recommended that development facilities be constructed to withstand shaking from a 7.5 magnitude earthquake. The largest earthquake in the State occurred on the island of Hawaii in 1868, having a magnitude of 7.5.

f. Tsunami. Tsunamis are large sea waves usually generated by movement of large submarine rock masses or volcanic eruptions. These waves can travel great distances at speeds of almost 500 miles per hour and move on shore turbulently or morely rise quietly.

The tsunami hazard is probably localized to a zone of land approximately 2 kilometers wide along the coast, and at elevations not much higher than 75 feet. This is not expected to pose a significant danger to geothermal developments which are likely to be situated at higher elevations.

(Exhibit No. 12, Circular C-107, Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas)

Compatibility with Land Uses.

Geothermal development may in some instances not be strictly compatible with surrounding land uses or the objectives and policies of state and county zoning designations. We believe that rather than strict compatibility, an acceptable relationship between differing objectives and policies should be sought. An acceptable relationship is one in which mitigation of impacts can be achieved; one in which a buffer can be provided; one which the need for development of the geothermal resources is balanced against the mitigated impacts.

In addressing land use compatibility, several assumptions were made.

- o Ambient air quality will not be affected since it is expected that current abatement technology will be fully utilized in compliance with proposed State Department of Health air quality standards for geothermal development.
- o Proposed County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with. It is also assumed that the County of Maui will adopt similar noise guidelines in reference to geothermal activities.
- o Geothermal facility siting will be adjusted to avoid endangered plants and significant archaeological or historical sites.
- o Visual impacts will be minimized by adjusting the location of the site, the alignment of structures so as to present the smallest possible aspect and by blending structures with surroundings by painting appropriately and by use of non-reflective, light absorbent materials and textures and by shielding facilities from view by locating behind a puu, or hill, or by placement in a forested area.
- o Impacts will be further minimized by use of buffer zones surrounding geothermal facilities.

Given these assumptions, it was concluded that compatibility with existing land uses and zoning can be achieved, and a subzone designated where clearly there exists a potential for production, prospect for utilization, mitigation of geologic hazards, and potential economic benefit to the people of the state.

a. State Land Use Districts. The State Land Use Commission has place all lands in the State in four major land use districts, urban, rural, agricultural and conservation which are described as follows in Chapter 205, HRS.

Urban Districts include those lands that are now in urban use and activities or uses as provided by ordinances or regulations of the county within which the urban district is situated.

Rubal Districts include activities or uses as characterized by low density residential lots of not more than one dwelling house per one-half acre and where small farms are intermixed with the low density residential lots.

Agricultural Districts include activities or uses as characterized by the cultivation of crops, orchards, forage and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters, mills, storage facilities, porcessing facilities; and roadside stands for the sale of products grown on the premises; and agricultural parks and open area recreational facilities.

Conservation Districts include areas necessary for protecting watershed and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

Geothermal rsource areas were found to contain both conservation and agricultural land use districts as well as urban and in one instance, a rural land use district.

b. Conservation Districts and Subzones. Conservation means a practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural and scenic resources attendent to land including territorial waters within the State, to ensure optimum long-term benefits for the inhabitants of the State. This definition, taken from the Department's Administrative Rule for Conservation Districts, clearly states basic conservation objective. Four subzones within the Conservation District range from the most restrictive, Protective Subzone, to the least restrictive, the General Subzone. The Conservation District constitutes a large portion of geothermal resource areas.

c. County General Plans and Land Use Policies. Urban, rural and agricultural state land use districts are administered by individual counties through their general plans, which set forth County objectives and policies for long range development, and community plans which provide more detailed schemes for implementing general plans.

(Exhibit No. 10, Circular C1-6, "Environmental Impact Analysis of Potential Geothermal Resource Areas").

provide more detailed schemes for implementing general plans.

(Exhibit No. 10, Circular C1-6, "Environmental Impact Analysis of Potential Geothermal Resource Areas").

D. Second Series of Public Participation and Information Meetings.

1. The second public informational meetings were used to identify potential subzone impact issues and solicit comment on the issues presented and to identify any omitted concerns. Information gathered was used by the Board in analyzing impacts and making subzone recommendations. After evaluating the seven potential geothermal resource areas on the basis of resource availability, prospects for utilization and examining the social, environmental, economic, geologic hazards, compatibility with land use, in addition to the statutory State energy objectives and policies, the following site was determined as deserving consideration for designation as a geothermal resource subzone by the Board of Land and Natural Resources: Kilauea Upper East Rift, Hawaii.

E. Evaluation of Kilauea Upper East Rift Zone.

As stated in Act 296, it was intended that the Board select areas that can best demonstrate an acceptable balance among the criteria set forth in the Act. The following summarizes the assessment of that criteria in the Upper Kilauea East Rift Zone.

Potential for Production.

A Geothermal Resources Technical Committee was formed to assist the Department of Land and Natural Resources in the identification of potential geothermal resources in Hawaii.

Upon evaluation of currently available data, the technical committee provided an estimate of percent probability for high temperature (greater than 125°C) geothermal resource. The consensus of the technical committee was that the Kilauea Upper

East Rift Zone had a greater than 90% chance probability for high temperature geothermal resource at a depth of less than 3 km.

On the basis of positive geotechnical data and the recent eruptive and intrusive activity, the Kilauea Upper East Rift was determined to have sufficient potential for a high temperature geothermal resource capable of producing electrical energy.

Prospects for Utilization.

Private geothermal development on the island of Hawaii has been stimulated by a request for proposal (RFP) issued in December 1980 by Hawaii Electric Light Co., Inc. (HELCO) for geothermally generated electrical power to meet their projected power requirements in 1988.

True/Mid-Pacific Geothermal Venture has successfully passed the qualifying Phase I which required preparation of a comprehensive development plan. In addition, the developer has prepared an environmental impact statement and has received conditional approval of a Conservation District Use Permit to explore for geothermal resource in the area of the Kilauea Upper East Rift Zone.

It was therefore concluded that there exists a definite prospect for the use of geothermal energy to meet the needs of the public and achieve a step toward the goal of energy self-sufficency for the State of Hawaii.

Geologic Hazards

Potential geologic hazards include lava flows, ash fallout, ground swelling and subsidence, earthquakes, ground cracking or faulting and tsunami.

Various methods which could be utilized to mitigate dangers from geologic hazards have been outlined in Exhibit No. 12. These methods include strategic siting, special construction designs and fortifications, evacuation planning, decentralization of power plants, and giving development investors a clear economic incentive to utilize mitigation methods by having them assume a major portion of the associated risks of loss. No attempt is made to prioritize methods since priorities may differ with the risks at each specific site and should be addressed during the permit application process.

Historic eruptions have occurred within the proposed Kilauea Upper East Rift Zone in 1963, 1965, 1969, 1977 and 1983-84. The current Pu'u O eruptive activity has covered an area of approximately 30 km^2. This eruption began in 1983 and to date has been through 28 phases. It should be noted that within the proposed subzone area, ground elevation increases as you move away from the rift zone axis, thereby providing considerable protection to geothermal development located in this area of the subzone. In addition, while some flows from Pu'u O have proceeded in the northeasterly direction, the majority of flows in general have flowed south of the proposed subzone.

Geothermal development will be permitted only upon the cessation of the current volcanic activity. Cooled lava flows such as those areas that have been covered by recent flows are likely to be used for well sites, while safer northern areas are expected to be used for power generation facilities. Furthermore, guidelines will be implemented by requiring developers to meet specific conditions to insure public safety prior to the granting of a geothermal resource permit by the State or appropriate county agency.

It was therefore concluded that the utilization of appropriate mitigation measures and careful site selection should result in an optimum balance of safety and production.

Social Impacts.

The major social concerns examined were health, noise, lifestyle, culture and community setting, and aesthetics.

Health Aspects.

The current level of abatement technology available for use in geothermal development is capable of removing 99% of the H_2S contained in nondensable gases. The recommended H_2S abatement system is called the Stretford System.

Use of this sytem would enable geothermal facilities to comply with proposed State Department of Health Air Quality Standards that require 98% of the H_2S present to be removed.

Noise Aspects.

During the initial phases of geothermal development, such as well drilling, production testing and well bleeding, residents in the vicinity of a geothermal site may be exposed to noise levels varying from 40 to 120 decibels, depending upon the distance from the well site.

Construction of a rock muffler in addition to acoustical baffling should reduce noise levels to about 44 decibels at the fence line of the project. Use of noise abatement technology would thereby insure compliance with County of Hawaii geothermal noise level guidelines of 45 decibels at night and 55 decibels by day.

Lifestyle, Culture and Community Setting.

The location of the proposed geothermal resource subzone is set back away from the Volcano community, Hawaii Volcanoes National Park and the Wao Kele O Puna Natural Area Reserve. The location is far enough away from present or anticipated population centers to allow for mitigation of any potential impacts to the residents in the community.

Aesthetic Aspects.

Since most geothermal resource rift zones are located in remote wilderness areas, development facilities must consider preservation of natural beauty and aesthetics.

Careful siting, landscaping, well designed plant architecture integrated with the use of buffer zones can insure the maintenance of natural qualities in the Kilauea Upper East Rift Zone.

It was therefore concluded that potential social im~~o~~pacts will be minimized by the utilization of proper mitigation measures required on a site-by-site basis during the subsequent permitting process.

Environmental Impact.

The general impact of geothermal development to the environment will be in the areas of air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

A significant impact on the flora and f~~l~~auna c~~w~~ould possibly occur within the proposed subzone area. A major portion of this subzone area consists of Category 1 forests classified as "exceptional native forest; closed canopy, over 90% native cover". (Reference: Exhibit No. 13)

Flora and Fauna. There are no endangered plant species known to exist in the Kilauea Upper East Rift Zone. Of the numerous rare plants, only the endemic Hawaiian fern, Adenophorus periens is known to exist in the Kahauale'a section of the Kilauea East Rift Zone. Protection of this species will be undertaken at the time specific geothermal development sites are identified and botannical surveys completed.

Forested areas in the upper portion of the East Rift Zone consist primarily of Category 1, exceptional native forest with over 90% native cover and closed canopy, and Category 2 mature native forest with over 75% native cover interspersed with bare lava flows, dated 1968-1973, 1977 and 1983-84.

Essential endangered species habitat for O'u encompasses a major portion of the Kahauale'a area, and extends into the Hawaii Volcanoes National Park land to the south.

While a major portion of this proposed subzone area is situated in high quality native forest and an endangered species habitat, only 25% of this habitat in the Kahauale'a area has been proposed for subzone designation.

We believe that site development may impact the endangered O'u habitat and native forest, but with careful planning and minimal removal of vegetation and trees, development activities should not significantly threaten existing flora and fauna.

Surface and Ground Water Impacts.

Ground water occurs as dike water and basal water in the Kilauea East Rift Zone. The only known perched water exists north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic gradients along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels.

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 18,000 mg/l. Because of the effects of mixing, most ground water at the coast is brackish. Salinity and temperature vary greatly north and south of the rift zone. Wells and shafts north of the rift zone are characterized by lower temperatures and lower salinities.

Wells in and near Keaau have water temperatures of 66° to 68°F. The water temperature of wells near Pahoa ranges between 72° and 74°F. Wells located more than 3 miles inland generally have a chloride concentration of less than 20 mg/l. South of the rift zone, high well-water temperatures and salinities are encountered. The water temperature of the Malami-Ki well, 2783-01, in 1962 was 127°-130°F with salinity betwen 5500 and 7000 mg/l at pumping rates fo 100 to 480 gpm. The water temperature of thermal test well NO. 3 in 1974 was 199°F, with salinity of 2000 mg/l. The average chloride content of ground water south of the rift zone is probably greater than 300 mg/l, probably due in part to heating of sea water by volcanic activity below the basal lens. The warmer, less dense sea water rises, contaminating the fresh water in the basal aquifer.

As noted earlier in this testimony, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the ground water aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions, and alternate safe disposal methods should be developed.

Air Quality. As noted earlier in this testimony ambient air quality conditions within the Kilauea East Rift Zone are being monitored. Baseline reports for the December 1982-December 1983 period indicate that in general measurements for total suspended particulates, hydrogen sulfide gas, and chlorine gases are very low, well below biological impact values.

Ambient mercury and radon values measured were found to be typical of atmospheric values nationwide for these elements.

The only exception was found in sulfur dioxide gas, which, due to volcanic eruptions during the period, exceeded standard values for urban areas, uman and plant health for days at a time. However, in the absence of volcanic activity, sulfur dioxide levels are low.

As noted earlier, use of the best available abatement technology will allow geothermal resource developers to comply with proposed State Department of Health air quality standards for geothermal development.

Noise Impact. In May of 1981, the County of Hawaii Planning Department issued a set of Geothermal Noise Level Guidelines to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. The County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with.

Historic and Archaeological Values. There are no known archaeological sites within the Upper Kilauea East Rift Zone. Should any sites be discovered during exploration and later development of geothermal facilities, facility location and road and pipeline alignments will be adjusted to avoid such sites and thereby minimize any impact to the site.

Scenic and Aesthetic Values. Development of geothermal facilities can represent visual intrusion. Observation of power plants from publicly accessible view points in the Volcanoes National Park and other areas outside the park is the primary visual concern in the Kilauea Upper East Rift Zone. A terrain analysis of visual impact was prepared for the Kahauale'a Environmental Impact Statement. Statements contained in that document indicate that some visual intrusion may occur in certain view corridors.

We believe visual impact can be minimized by well-planned siting of facilities, landscaping, and well designed plant architecture.

Recreational Values. Recreational values in remote areas such as Kahauale'a include hiking and hunting. These activities are not usually limited to specific areas and could occur anywhere. Geothermal development may in certain instances affect the number of game animals present and degrade hiking and recreation experiences found in remote wilderness areas.

It is concluded that there are potential impacts from geothermal development. However the recommendation to subzone this area was based on the assumption that through the utilization of current geothermal abatement technology as outlined in Exhibit 11, and with developer compliance with existing State Department of Health air quality standards and County noise guidelines, the risk from potential environmental impacts can be safely mitigated.

Compatibility of Geothermal Developmenmt with Existing Land Uses.

Land uses in the proposed subzone consist primarily of the forested areas of Kahauale'a - exceptional native forest and mature native forest interspersed with bare lava flows. As noted earlier, most of the forested areas provides habitat for the endangered O'u, a native forest bird.

Surrounding the subzone and separated from it by a 2000-foot buffer zone, land uses include the Hawaii Volcanoes National Park to the south and southwest, forested areas of Kahauale'a, including ~~extensive O'u habitat~~, between the subzone boundary and Highway 11, on the north, and the Wao Kele O Puna Natural Area Reserve on the east, also separated by a 2000-foot buffer zone. Included in the assessment of existing land is the Campbell

Estate True/Mid-Pacific Geothermal Development area approved for exploration by the Board of Land and Natural Resources in 1983.

Compatibility simply means living harmoniously, and obviously some land uses are more compatible than others.

We realize that geothermal development may in some instances not be strictly compatible with surrounding land uses, however, once potential impacts have been identified and mitigation measures assured, we do believe that it is possible to achieve an acceptable balance or relationship between the proposed development and the existing land use.

The provision of a 2000-foot buffer zone, emission abatement technology which will meet Department of Health air quality standards, use of mufflers and baffles to ensure compliance with County noise guidelines, siting, structure design, choice of building materials, alignments to minimize visual impacts - all serve to mitigate potential impacts and achieve greater compatibility with surrounding land uses in the proposed Kilauea Upper East Rift geothermal subzone.

Economic Impact.

Based upon the available data, the following scenerio was used in the economic assessment: that a 20 to 30 megawatt (MW) plant would built, and that the application of geothermal resource would be for the production of electricity for local consumption.

The selection of a 20 to 30 MW scenario was based n the projected optimum sign of the power generating unit to be used for local power distribution. This represents the total projected market for the new generation capacity based on the estimated growth in demand, combined with the reduction of existing fuel oil generation capacity.

The economic impact on a State-wide and County-wide basis would be in the area of direct wages to the 25 direct project employees of about $560,000 per year. This direct income could stimulate a multiplier effect totaling an estimated $1.3 million. Additionally, an estimated 57 additional jobs would be created.

Utilization of geothermal energy will also result in additional revenue to the State from royalties received for those sites on State owned lands or private lands with State mineral rights reservations. These royalties range from a minimum of 10 percent to 20 percent of the groww revenue produced. Assuming a 10 percent royalty rate based on our 20 to 30 MW scenario, the estimated gross annual revenue of $9.9 million would yield to the State approximately $1 million in annual revenue.

Independent of the size of the plant utilized in the assessment, a more definitive evaluation of the relative gain or loss due to geothermal development activities must be made on a case-by-case basis. In addition, direct use applications of geothermal resource would modify the plant size requirements and alter both benefits and costs realized by the existence of a geothermal plant.

Compatibility of Geothermal Development with the Uses Permitted in the Conservation District.

The Kahauale'a section of the Upper East Rift Zone is zoned Conservation, Limited Subzone. The objective of the Limited Subzone as stated in the Department's Administrative Rule, Title 13, Chapter 2, is to limit uses where natural conditions, such as volcanic activity, suggest constraints on human activities. As such, in accordance with the Administrative Rule, all uses permitted in the Protective Subzone are also permitted in the Limited Subzone; emergency warning systems, or emergency telephone systems are permitted; and flood, erosion, or siltation control projects are permitted as well as the growing and harvesting of forest products. While intermittent use of the Limited Subzone may be permitted, a constant use, such as a residence, is not.

Development of geothermal facilities would entail intermittent, limited use of the Conservation District by persons operating a geothermal facility. Evacuation of a limited number of individuals from an area in the event of volcanic activity can be accomplished quickly, thus conditional use of the Limtied Subzone could be allowed.

Although no portion of the Subzone is zoned Protective, the most restrictive Conservation District Subzone, all uses permitted in the Protective Subzone are also permitted in the Limited Subzone. Since use of the area for "monitoring, observing and measuring the natural resource" is permitted in the Protective Subzone, exploration for geothermal resources can and has been permitted by the Board of Land and Natural Resources.

Development of geothermal resourses can lead to widespread public benefit. Use of lands within the Conservation District, Protective Subzone, in which the public benefit outweighs any impact to the Conservation District, is also permitted. Public benefit from geothermal resources to be developed in the Upper East Rift Zone has been established and mitigation of potential impacts can be accomplished. As such, we believe an acceptable balance between geothermal development and the objectives of the Conservation District has been established.

F. Closing Remarks.

In closing, the Department of Land and Natural Resources believes that the record demonstrates full compliance with the Legislative intent of Act 296 and Act 151 directing the Board of Land and Natural Resources to designate geothermal resource subzones.

The record, consisting of all exhibits attached hereto, adequately and fully addresses the criteria for assessment indicted by the Legislature and contained in Act 296.

Information contained in the record is based on the currently available information as of this date and the technical input and guidance of a capable technical committee and division staff.

In summary, it should be noted that twenty separate areas in the State of Hawaii were identified as having potential geothermal resources. Of these, five sites on the island of Hawaii and two on the island of Maui were determined to have sufficient probability of locating high temperature geothermal resources with the potential of producing electrical energy. High temperature is defined to be greater than 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9,840 feet. After subjecting the seven areas to impact analysis by examining factors on geologic hazards, social and environmental impacts, compatibility with present uses of surrounding land, potential economic benefits, and compatibility with conservation areas, it was concluded that three areas warranted consideration for designation of geothermal resource subzones by the Board of Land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984.

On November 16, 1984, the Board designated the Kilauea Lower East Rift Zone and the Haleakala Southwest Rift Zone as Geothermal Subzones.

With respect to the Kilauea Upper East Rift Zone, we provide the following summary.

This area has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Significant impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been ~~identified to~~ habitat the area and high quality native forest are located north of the rift zone. Moderate impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, active volcanic activity centered on Puu O has been taking place in the area. The current volcanic flows are viewed as temporary in nature and when the activity ceases, drilling over the volcanic flow is considered feasible and desirable considering the effects on other environmental values in the surrounding areas.

The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2,000-foot buffer area to both the Volcanoes National Park and the Natural Area Reserve System. In addition, the encroachment into the native forest area has been minimized to concentrate exploration, development, and production activities towards the rift or volcanic flow areas. The northern boundary extends approximately 25 percent into the native forest area.

It should be noted that subzoning constitutes the first phase in the utilization of geothermal resources. Exploration, development and production will be subjected to subsequent case-by-case analysis prior to the issuance of State or County permits. No development activity can take place without meeting al the requirements specified in these permits.

After assessing all of the factors outlined in Act 296 based on currently available public information, the Department believes that the Kahauale'a area proposed for designation as a subzone meets the criteria of demonstrating an acceptable balance amongst the factors set forth in Act 296.

The Department of Land and Natural Resources therefore believes that the public benefit of geothermal development, as an alternate energy resource, far outweighs any mitigated impact on the natural resources of the Kilauea East Rift Zone.

In addition, it is vital for the State do proceed with the development of geothermal energy in order to reduce our dependency on imported fuel oil. The designation of geothermal resource subzones is the first step toward energy self-sufficiency for the State of Hawaii.

We recommend that the Board adopt our conclusion and grant the designation of the Kilauea East Rift Zone as a geothermal subzone.

Thank you.

Dated: Honolulu, Hawaii, December 7, 1984

Robert T. Chuck

ROBERT T. CHUCK
Manager-Chief Engineer
Division of Water and Land Development
Department of Land and Natural Resources
State of Hawaii

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Written Testimony of Robert T. Chuck of the Division of Water and Land Development, Department of Land and Natural Resources, State of Hawaii, was personally served on December 7, 1984 upon the following parties:

- Benjamin Matsubara and Stephanie Rezents, attorneys
  1717 Pacific Tower
  1001 Bishop Street
  Honolulu, Hawaii 96813

  Representing:
  - Estate of James Campbell (intervenor-applicant)
  - True/Mid-Pacific Geothermal Venture (intervenor-applicant)

- Wendell Y. Y. Ing, attorney
  (Ken Kupchak, co-counsel)
  209 Kinoole Street., Room 8
  Hilo, Hawaii 96720

  Representing:
  - Susan Carey (party)
  - Frederick Warshauer (party)
  - Diane Ley (party)
  - Volcano Community Association (party) c/o Russell Kokubun
  - Lehua Lopez (intervenor-applicant)
  - Eva Lee (intervenor-applicant)
  - Louis Whiteaker (intervenor-applicant)
  - Chiu Leong (intervenor-applicant)
  - Virginia B. MacDonald (intervenor-applicant)
  - Debra Hopson (intervenor-applicant)
  - Donald King (intervenor-applicant)
  - Marguerite King (intervenor-applicant)
  - Ann Markham (intervenor-applicant)
  - Mike Markham (intervenor-applicant)
  - Beverly MacCallum (intervenor-applicant)
  - Russell Apple (intervenor-applicant)
  - Matt Luera (intervenor-applicant)
  - Hawaii Audubon Society (intervenor-applicant)

In addition, the above Written Testimony of Robert T. Chuck was also served on December 7, 1984 via certified mail upon the following parties:

- Sierra Club, Hawaii Chapter (party)
  c/o Nelson Ho, Energy Chairman (representing himself)
  P. O. Box 590
  Mountain View, Hawaii 96771

- Mae Evelyn Mull (party - representing herself)
  P. O. Box 275
  Volcano, Hawaii 96785

- o James L. McIntosh, attorney
  161 Kalakaua Street, Suite 20
  Hilo, Hawaii 96720

  Representing: National Parks and Conservation Association

- o Thomas L. H. Yeh, Deputy Corporation Counsel
  County of Hawaii, Planning Department
  25 Aupuni Street
  Hilo, Hawaii 96720

DATED: Honolulu, Hawaii, December 7, 1984.

Robert T. Chuck

ROBERT T. CHUCK
Manager-Chief Engineer
DIVISION OF WATER AND
LAND DEVELOPMENT,
DEPARTMENT OF LAND AND
NATURAL RESOURCES

BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of Kahauale'a, Puna, Hawaii as a Geothermal Resource Subzone	)	GS No. 8/27/84 TABLE OF CONTENTS OF WRITTEN TESTIMONY FOR CONTESTED CASE HEARING

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2. GERALD NIIMI
   Exhibit A: List of Credentials and Professional Experience.

3. CHARLES H. LAMOREUX, PH. D. (Botanist)
   Exhibit A: List of Credentials and Professional Experience.

TESTIMONY OF CHARLES HELSLEY, PH.D.
FOR CONTESTED CASE HEARING

Chairman and Members of the Board of Land and Natural Resources, I am Dr. Charles Helsley, a professor of geophysics at the University of Hawaii and Director of The Hawaii Institute of Geophysics. I am testifying in my individual capacity today and not as a representative of the University. I have a Bachelor of Science and a Master of Science Degree in Geology from the California Institute of Technology and received my Doctor of Philosophy Degree in Geology from Princeton University. I have been actively involved in the field of geophysics for over 25 years.

I have reviewed the Statewide Geothermal Resource Assessment (Circular C-103) and the Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas (Circular C-107) and believe that these documents are an excellent appraisal of the geothermal resource potential in the State of Hawaii. The Technical Committee's approach and analysis was very professional and thorough. Based on my experience as a geologist and as a participant in the evolution of geothermal energy in Hawaii, I wholly concur with the findings.

As far as geologic hazards are concerned, all parts of the rift zone of Kilauea are subject to lava inundation and this fact is well recognized by all the developers. Circular C-107 succinctly summarizes these potential hazards and the possible mitigation efforts that could be attempted. Almost all of the issues have been discussed previously in the Kahaualea EIS or the testimony related to the various hearings associated with the Kahaualea CDUA. This testimony is in fact the basis of some of the statements in C-107.

Perhaps one point brought out in C-107 needs to be emphasized. Since the geothermal resources of Kilauea are intimately associated with the cause of the volcanic hazard, it is essential for the welfare of the public that the geothermal development be distributed. Any individual eruption rarely, if ever, affects both the Lower and Upper East Rift Zone yet any one eruption could disrupt operations in either area. Thus it is essential for electrical power generating capacity stability that at least some facilities be developed in both areas. The distributed, yet interconnected, powerplant sites (A, B, C, D) proposed for the Kahaualea project clearly recognized this need for separation so that all of one's facilities would not be disturbed by any one event. But to do this one must have facilities. The geothermal resource subzone for the upper portion of the East Rift zone as proposed by DLNR provides the necessary room to accomplish this separation. Moreover, the development plan presented in the CDUA provided a series of interconnected access roads into the area that is most likely to be affected by lava with the full realization that alternate evacuation routes would be necessary in case of emergency. In the proposed plan only the main access road which is unlikely to be subject to lava hazard is not redundant.

In evaluating the impact of geologic hazards, I believe that Figure 8 in "A Report on Geothermal Resource Subzones for Designation by the Board of Land and Natural Resources" should be revised slightly to show that the Lower Kilauea East Rift is subject to being impacted by ground cracks and ground subsidence. My opinion is based mainly on Figures 14 and 15 in Circular C-107. Figure 14 highlights the areas believed subject to relatively high risk of subsidence. Figure 15 delineates areas with high, medium, and low risk of surface rupturing. It is apparent to me that both the Lower and Upper East Rift is subject to high risk of subsidence and high risk of surface ruptures. All other things being equal, the Upper Rift Zone should not be excluded from geothermal subzone designations because of impacts of geologic hazards.

Finally, the current hazard associated with the Pu'u O eruption is an economic hazard, rather than a "people" hazard, that has always been recognized by the developers. This eruption will eventually end, as all eruptions do, and in my opinion the current activity supports rather than detracts from the economic viability of the proposed Kahaualea project.

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Hawaii Institute of Geophysics

HELSLEY, CHARLES E. Birth Date: 6/24/34
Oceanside, California

Professor and Director

DEGREES

B.S., Geology, California Institute of Technology, 1956
M.S., Geology, California Institute of Technology, 1957
Ph.D., Geology, Princeton University, 1960

FIELDS OF RESEARCH SPECIALIZATION

Paleomagnetism and Rock Magnetism
Crustal Seismology and Marine Geophysics

ACTIVE RESEARCH SPECIALIZATION

Studies of the past behavior of the earth's magnetic field and their implications regarding polar wander and continental drift.
Geophysical studies of crustal structure at continental margins.
Magnetic reversal stratigraphy of Mesozoic and Paleozoic rocks.
Energy Resources - Geothermal and Wind

EXPERIENCE

1956-1957, California Institute of Technology, Field Geology, Graduate Teaching Assistant. Summers: Shell Oil Company, Los Angeles, Exploitation Engineer
1957-1958, Princeton University, Graduate Teaching Assistant, Instructor in Beginning Physical Geology
1960-1962, California Institute of Technology, Geology, Assistant Professor
1962-1963, Western Reserve University, Geology, Assistant Professor
1963-1976, Southwest Center for Advanced Studies (now The University of Texas at Dallas)
1964-1976, Southern Methodist University, Department of Geophysics, Adjunct Professor
1969-1970, University of Texas at Austin, Visiting Professor
1970-1971, Acting Division Head, Geosciences, The University of Texas at Dallas
1971-1973, Associate Head, Geosciences, The University of Texas at Dallas

EXHIBIT "A"

1973-1976, Program Head and Institute Director, Institute for Geosciences, The University of Texas at Dallas
1974-1976, The University of Texas Medical Branch at Galveston, Marine Biomedical Institute, Earth and Planetary Sciences Division, Adjunct Professor
1976- , Director, Hawaii Institute of Geophysics, University of Hawaii

OUTSIDE ACTIVITIES

Chairman, JOIDES Gulf Advisory Subpanel, 1970-74
Member, NSF Advisory Panel, Earth Sciences, 1971-74
Member, Board of Trustees, GURC, 1973-1975
Member, IASPEI Crustal Seismology Group, 1973-
Member, IUGS Subcommission on The Magnetic Polarity Time Scale, 1972-
Correspondent, U. S. Geodynamics Committee, 1973-74
Reporter, Magnetic Problems, U. S. Geodynamics Committee, 1974-
Member, COCORP Site Selection Committee, 1974-80
Member, JOIDES Executive Committee, 1976-
Member, JOIDES Planning Committee, 1976-1977
Chairman, Geophysics Division, Geological Society of America, 1976-1978
Vice-President, JOI Inc., 1976-80
Member, Regional Studies Committee of JOI Inc., 1976-77
Member, U. S. Geodynamics Committee, 1976-1979
Member, Governor's Marine Affairs Advisory Committee, 1977-
President-elect, Geomagnetism and Paleomagnetism, AGU, 1978-80
Member, State Geothermal Advisory Committee, 1978-
Member, Advisory Committee of the Hawaii GEothermal Project/Development Group, 1978-
President, Geomagnetism and Paleomagnetism, AGU, 1980-81
Member, Board of Governors, JOI Inc., 1976-

PUBLICATIONS

"Paleontologic Technique for Defining Ancient Pole Positions," with F. G. Stelhi, Science, 142, 1057, 1963.

"Comparison of Permian Magnetic and Zoogeographic Poles," with F. G. Stehli, in Problems in Paleoclimatology, A. E. M. Nairn, Editor, N.A.T.O. Paleoclimates Conference, Newcastle upon Tyne and Durham, England, 1963 Proc., Interscience Publishers, p. 705, London, 1964.

"Determination of the Relative Positions of Continents from Paleomagnetic Data," with K. W. T. Graham and A. L. Hales, J. Geophys. Res., 69, 18, pp. 3894-3900, 1964.

"Paleomagnetic Results from the Lower Permian Dunkard Series of West Virginia," J. Geophys. Res., 70, 2, 1965.

"Polar Wandering and Continental Drift," 1966 McGraw-Hill Yearbook of Science and Technology, McGraw Hill Co., New York, 1966.

"Some Logistics of the East Coast On-shore Off-shore Experiment," (ECCOE), with A. L. Hales, J. J. Dowling, and J. B. Nation, Earthquake Notes, XXXVII, pp. 25-32, 1966.

"Advantages of Field-Drilling Samples for Paleomagnetic Studies," in Methods in Paleomagnetism, D. W. Collinson, K. M. Creer and S. K. Runcorn, Editors, Elsevier Publishing Co., Amsterdam, pp. 26-30, 1967.

"Design of a Transistorized Portable Air Turbine Spinner Magnetometer," in Methods in Paleomagnetism, D. W. Collinson, K. M. Creer and S. K. Runcorn, Editors, Elsevier Publishing Co., Amsterdam, pp. 142-148, 1967.

"Design of Spinner Magnetometers," in Methods in Paleomagnetism, D. W. Collinson, K. M. Creer and S. K. Runcorn, Editors, Elsevier Publishing Co., Amsterdam, pp. 115-118, 1967.

"The Gulf Coast On-shore Off-shore Experiment: Some Preliminary Results," with A. L. Hales and J. B. Nation, Trans. Am. Geophys. Un., 48, 2, pp. 753-756, 1967.

PUBLICATIONS (cont.)

"The Taxonomic Diversity of Recent Bivalves and Some Implications for Geology," with F. G. Stehli and A. L. McAllister, Bull. Geol. Soc. Am., 78, pp. 455-466, 1967.

"The East Coast On-shore Off-shore Experiment, 1. The First Arrival Phases," with A. L. Hales, J. J. Dowling and J. B. Nation, Final Report, Contract No. AF 49(638)-1952 to the U. S. Air Force Officer of Scientific Research, March 31, 1967.

"Paleomagnetism of Cretaceous Rocks from North America," Okla. Geol. Surv., 28, 3, pp. 116-117, 1968b.

"Magnetic Reversal Stratigraphy of the Lower Triassic Moenkopi Formation of Western Colorado," Bull. Geol. Soc. Am., 80, pp. 2431-2450, 1969.

"Evidence for Long Intervals of Normal Polarity during the Cretaceous Period," with M. B. Steiner, Earth and Planet. Sci. Letters, 5, pp. 325-332, 1969.

"Magnetic Properties of Lunar Dust and Rock Samples," Science, 167, 693-695, 1970.

"The Paleomagnetism of Cretaceous Rocks from Israel," with A. Nur, Earth and Planet. Sci. Letters, 8, 6, pp. 403-410, 1970.

"P Travel Times for an Oceanic Path," with A. L. Hales and J. Nation, J. Geophys. Res., 75, pp. 7362-7381, 1970.

"A Crustal Structure Study on the Gulf Coast of Texas," with A. L. Hales and J. B. Nation, Bull. AAPG, 54, 11, 1970.

"Summary of the Geology of the British Virgin Islands," Proc. of the 5th Caribbean Geological Conference, #5, 69-76, 1971.

"Remanent Magnetization of the Permian Cutler Formation of Western Colorado," J. Geophys. Res., 76, 20, 4842, 4848, 1971.

"Paleomagnetism of Tertiary and Recent Lavas of Israel," Physics of the Earth and Planet. Sci. Letters, 10, pp. 375-379, 1971.

"Magnetic Properties of Apollo 11 Samples 10022, 10069, 10084, and 10085," in Proc. of the Apollo 11 Lunar Science Conference, A. A. Levinson, Editor, Pergamon Press, New York/London, 3, p. 2213, 1971.

PUBLICATIONS (cont.)

"Evidence for an Ancient Lunar Magnetic Field," Proc. of the Second Lunar Science Conference, Vol. 3, pp. 2485-2490, The M.I.T. Press, 1971.

"Paleomagnetic and Rock Magnetic Studies of the Permian Cutler and Elephant Canyon Formations, Utah," with W. A. Gose, J. Geophys. Res., 77, 8, pp. 1534-1548, 1971.

"Are Lunar Rilles Inverted Eskers," Geol. Soc. Am. Memoir, 132, pp. 661-668, 1972.

"Jurassic Polar Movement Relative to North America," J. Geophys. Res., 77, pp. 4891-4993, 1972.

"The Significance of the Magnetism Observed in Lunar Rocks," in The Moon, An International Journal of Lunar Studies, H. Alfven, Z. Kopal and H. C. Urey, Editors, 1972.

"Remanent Magnetization of a Long Core from the Moenkopi Formation," with C. Baag, Bull. Korean Geol. Soc., 60th Birthday Memorial Edition of Prof. Chi-Mu Son, p. 241, 1972.

"Magnetic Reversal Sequence in the Upper Portion of the Chinle Formation, Montoya, New Mexico," with S. C. Reeve, Geol. Soc. Am. Bull., 82, 12, 1972.

"Paleomagnetism of 1140 to 1150 Million-Year Diabase Sills from Gila County, Arizona," with H. Spall, J. Geophys. Res., 77, 11, pp. 2115-2128, 1972.

"Jurassic Polar Movement Relative to North America," with M. G. Steiner, J. Geophys. Res., 77, 26, pp. 4981-4993, 1972.

"Heat Flow and Continuous Seismic Profiles in the Cayman Trough and Yucatan Basin," with A. J. Erickson and G. Simmons, Geol. Soc. Am. Bull., 83, pp. 1241-1260, 1972.

"Shape Analysis of Paleosecular Variation Data," with C. Baag, J. Geophys. Res., 79, 22, pp. 4923-4932, 1974.

"Geomagnetic Secular Variation Model E," with C. Baag, J. Geophys. Res., 79, 32, pp. 4918-4922, 1974.

"Remanent Magnetization of a 50 m Core from the Moenkopi Formation, Western Colorado," with C. Baag, Geophys. Jour. of the Royal Astron. Soc., 37, pp. 245-262, 1974.

PUBLICATIONS (cont.)

"Evidence for Penecontemporaneous Magnetization of the Moenkopi Foramation," with C. Baag, J. Geophys. Res., 79, pp. 3308-3320, 1974.

"Paleomagnetism of the Lower Triassic Moenkopi Formation," with M. B. Steiner, Geol. Soc. Am. Bull., 85, pp. 457-464, 1974.

"Reproducible Anomalous Upper Triassic Magnetization," with M. B. Steiner, Geology, 2, pp. 191-194, 1974.

"Magnetic Polarity Sequence of the Upper Triassic Kayenta Formation," with M. B. Steiner, Geology, 2, pp. 195-198, 1974.

"Paleomagnetic Results from the Upper Triassic of East Greenland," with S. C. Reeve, D. Leythauser and K. Bay, J. Geophys. Res., 79, 23, pp. 3302-3307, 1974.

"Mesozoic Reversal Sequence," with R. Larson, Reviews of Geophys. and Space Phys., 13, 3, pp. 174-176, 1975.

"Reversal Pattern and Apparent Polar Wander for the Late Jurassic," with M. B. Steiner, Geol. Soc. Am. Bull., 86, pp. 1537-1543, 1975.

"Late Jurassic Magnetic Polarity Sequence," with M. B. Steiner, Earth and Planet. Sci. Letters, 27, pp. 108-112, 1975.

"Late Cretaceous Reversal Sequence," with B. Keating and E. A. Pessagno, Jr., Geology, pp. 73-76, 1975.

"Project Nariño III: Refraction Observation across a Leading Edge, Malpelo Island to the Colombian Cordillera Occidental," with R. P. Meyer, W. D. Mooney, A. L. Hales, G. P. Woollard, D. M. Hussong, L. W. Kroenke, and J. E. Ramirez, Geophysical Monograph 19, Am. Geophys. Un., pp. 105-132, 1976.

"Observations made by the University of Texas at Dallas in Project Nariño," with A. L. Hales and J. B. Nation in Nariño Project: The Ocean - Continent Transition in SW - Colombia, J. E. Ramirez and L. T. Aldrich, Editors, Instituto Geofisico - Universidad Javerianna, Bogota, Colombia, pp. 281-300, 1977.

"Geothermal Potential for Hawaii in Light of HGP-A," in Geothermal: State of the Art, Geothermal Resources Council, Davis, CA, pp. 137-138, 1977.

"Magnetostratigraphy of Cretaceous Age Sediments from Sites 361, 363, and 364," with B. Keating, Initial Reports of the Deep Sea Drilling Project, 40, pp. 459-467, 1978.

"Magnetostratigraphic Studies of Cretaceous Sediments from DSDP Site 369," with B. Keating, Initial Reports of the Deep Sea Drilling Project, 41, pp. 983-986, 1978.

"Paloemagnetic Results from DSDP Site 391C and the Magnetostratigraphy of Cretaceous Sediments from the Atlantic Ocean Floor," with B. Keating, in W. E. Benson and R. E. Sheldan et al., Initial Reports of the Deep Sea Drilling Project, 44, pp. 523-528, 1978.

"Explosion Seismology Studies of Active and Passive Continental Margins," with B. Keller, B. T. R. Lewis, C. Meeder, and R. P. Meyer, AAPG Memoir, 27, pp. 443-451, 1978.

"Magnetostratigraphic Studies of Cretaceous Sediments from DSDP Site 386," with B. Keating, Initial Reports of the Deep Sea Drilling Project, 43, pp. 781-784, 1979.

"Magnetostratigraphy of the Cretaceous," with B. Keating, in E. Kaufman and B. Haile (ed.), The North Temperate Cretaceous. (In press)

"Paleomagnetic Studies in the Indian Ocean, Position of Madagascar," with B. Keating, Geology. (In prep.)

"Patterns of Local Seismicity Preceding the Petatlan Earthquake of March 14, 1979," with J. F. Gettrust, V. Hsu, E. Herrero, and T. Jordan, Bull. Seis. Soc. Am., 1981. (In press

"Foreshock Characteristics of the March 14, 1979 Petatlan Earthquake," with V. Hsu, and J. F. Gettrust. (In prep.)

"Breaking of A Seismic Gap; Local Seismicity Preceding the March 14, 1979 Petatlan Earthquake," with V. Hsu, and J. F. Gettrust. (Submitted to Jour. Geophys. Res.)

"Magnetostratigraphy of the Moenkopi Formation at Bears Ears, Utah," with B. R. Lienert, J. Geophys. Res., 85, pp. 1475-1480.

"Origin and Alteration of Stable Remanence in Continental (non-red) Sediments from the Lance Formation, Southeastern Wyoming," with B. Keating, International Asso. Geomagnetism and Aeronomy Proceeding, Seattle Meeting, 1977.

"Nature of the 'Cretaceous Quiet Interval,'" with B. Keating, EOS, Trans. Am. Geophys. Un., 58, 8, 740, 1977.

"Cretaceous Magnetostratigraphy," with B. Keating, Fifth European Geophysical Society Meeting, Abstracts Volume, 71, 1978.

"Cretaceous Magnetostratigraphy," with B. Keating, EOS, Trans. Am. Geophys. Un., 60, 237, 1979.

"Paleomagnetic Results from Truk Lagoon, Western Pacific Ocean," with B. Keating, E. Herrero-Bervera, J. Thompson and J. Naughton, EOS, Trans. Am. Geophys. Un., 218, 1980.

"Cretaceous Magnetostratigraphy," with B. Keating, Abstract, IAGA meeting, Edinburgh, 1981. (In press)

"Evidence for a New Pacific Hot Spot," with B. Keating, D. Mattey, J. Naughton, and D. Epp, EOS, Trans. Am. Geophys. Un., 1981. (In press)

"Magnetostratigraphy of Lower Triassic Strata in the Western United States," Abstract, IAGA Meeting, Edinburgh, 1981 (In press)

"Paleomagnetism of A Lower Triassic Polarity Transition," with E. Herrero-Bervera and V. Hsu, Abstract, IAGA meeting, Edinburgh, 1981 (In press)

PAPERS PRESENTED AT NATIONAL MEETINGS

"Remanent of Some Jurassic Red Limestones from the Alps," (abstract) American Geophysical Union, 1962.

"Paleomagnetic Results from Precambrian Rocks of Central Arizona and Duluth, Minnesota," (abstract) Trans. Amer. Geophys. Un., 46, 1, p. 67, 1965.

"A Compilation of Paleomagnetic Investigations of Rocks from North America," with H. R. Spall, Trans. Amer. Geophys. Un., 47, 1, March 1966.

"Normal and 'Anomalous" Paleomagnetic Results from the Tertiary and Recent Lavas of Israel," (abstract) with Amos Nur, Trans. Amer. Geophys. Un., 48, 1, p. 82, 1967.

"Paleomagnetism of Cretaceous Rocks from North America," (abstract) Trans. Amer. Geophys. Un., 48, 2, p. 73, 1967.

"Paleomagnetic Evidence for Time-Transgressive Lithologic Units in Moenkopi Formation" (abstract) Trans. Amer. Geophys. Un., 50, p. 607, 1969.

"Secular Variation in the Lower Triassic Moenkopi Formation," (abstract) with M. B. Steiner, Trans. Amer. Geophys. Un., 52, 4, p. 189, 1971.

"Remanent Magnetization of a Long Core from the Moenkopi Formation," (abstract) with C. Baag, Trans. Amer. Geophys. Un., 1971.

"Rapid Polar Motion in the Carboniferous of North America," with G. R. Scott, E.O.S., Trans. Amer. Geophys. Un., 54, 4, p. 243, 1973.

"Paleomagnetism of the Lower Carboniferous St. Joe Limestone of Arkansas, with G. R. Scott, E.O.S., Trans. Amer. Geophys. Un., 54, 11, p. 1076, 1973.

"Geomagnetic Polarity Transitions Recorded in the Moenkopi Formation, with C. Baag, E.O.S., Trans. Amer. Geophys. Un., 55, 4, p. 225, 1974.

"Paleomagnetic Results from the Late Paleozoic Maroon Formation, with F. D. Christensen, E.O.S., Trans. Amer. Geophys. Un., 55, 4, p. 225, 1974.

"A Paleomagnetic Investigation of the Lower Triassic State Bridge Formation in Northcentral Colorado, with F. D. Christensen, E.O.S., Trans. Amer. Geophys. Un., 56, 12, p. 1170, 1974.

PAPERS PRESENTED AT NATIONAL MEETINGS (cont.)

"Magnetization of the Wingate and Chinle Formations, Southeastern Utah," with S. C. Reeve, E.O.S., Trans. Amer. Geophys. Un., 56, 12, p. 1170, 1974.

"Paleomagnetic Evidence for Post-Jurassic Tectonic Stability of Southeastern Mexico," with J. Guerro, E.O.S., Trans. Amer. Geophys. Un., 56, 12, p. 1170, 1974.

"Magnetic Field Polarity during the Late Jurassic," with M. B. Steiner, E.O.S., Trans. Amer. Geophys. Un., 56, 6, p. 354, 1975.

"Reversed Events whether the Late Cretaceous Normal Polarity Interval," with B. H. Keating and E. A. Pessagno, Jr., E.O.S. Trans. Amer. Geophys. Un., 56, 6, p. 354, 1975.

"Seismic Refraction Observations in Southern Mexico," with J. B. Nation and R. P. Meyer, E.O.S., Trans. Amer. Geophys. Un., 56, 6, p.452, 1975.

"Refracted Waves Across A Leading Edge: Observations of Pacific Shots in Southern Mexico," with W. M. Mooney, R. P. Meyer, C. Lomnitz, and B. T. R. Lewis, E.O.S., Trans. Amer. Geophys. Un., 56, 6, p. 452, 1975.

"Magnetization of Rhyolites from DSDP Hole 207A," for Conference on the Nature of the Oceanic Crust, with B. Keating, E.O.S., Trans. Am. Geophys. Un., 57, 5, p. 395, 1975.

"Field Evidence for the Time of Origin of the Magnetization of Redbeds," E.O.S., Trans. Amer. Geophys. Un., 57, 4, p. 241, 1976.

"Cretaceous and Tertiary Movement of the Pacific Plate: Paleomagnetic Evidence from DSDP Si-es 165, 199, 288A, 289, and 317A," with B. Keating, S. R. Hammond, and F. Theyer, E.O.S., Trans. Amer. Geophys. Un., 57, 12, p. 932, 1976.

"Magnetostratigraphy of the Cretaceous," with B. Keating, Abstracts with Program, Geol. Soc. of America Annual Meeting, Dallas, v. 8, no. 6, p. 948, 1976.

"Plate Motion of the Western Indian Ocean and Madagascar," with B. Keating, E.O.S., Trans. Am. Geophys. Un., 58, 6, p. 376, 1977.

Testimony of Gerald Niimi
for
Contested Case Hearing

I. BACKGROUND

Mr. Chairman and Members of the Board of Land and Natural Resources, this report is submitted on behalf of the True/Mid-Pacific Joint Venture and the Estate of James Campbell, developers and landowners of Kahauale'a located in the Puna District, Island of Hawaii. Kahauale'a is located in the East Rift Zone of Kilauea Volcano where geothermal steam and hot water have been discovered and is being produced approximately 13 miles away in the Lower Rift Zone.

The purpose of this report is to present information to the Board of Land and Natural Resources to support the Staff recommendation designating Geothermal Subzones in the State of Hawaii (Circular C-103). In addition to resource related areas, I have included additional information relative to Geologic Hazards(Circular C-107) and Geothermal Technology (Circular C-108).

I have worked directly in the geothermal industry since 1978 in engineering and management capacities. My expertise is in resource assessment, reservoir engineering, well testing, and operations management. I have advised clients in many areas of the U.S. and the world. My background is both diverse and practical such that I believe my comments would be pertinent in planning and operating a geothermal project. Prior to working in the geothermal industry, I had 10 years of experience in the oil industry in both staff and supervisory positions. Those 10 years were spent working on major projects for Exxon Company USA in Texas, California, and Alaska. I am a Registered Petroleum Engineer in the State of California.

II. RESOURCE EVIDENCE IN KAHAUALE'A, UPPER EAST RIFT

Based on my review of the Statewide Geothermal Resource Assessment Report (Circular C-103), I strongly concur with the Technical Committee's recommendations. I also concur with their methodology in arriving at the location and extent of the high temperature geothermal resources. The Staff and Technical Committee should be complemented for their work, particularly in the face of a very tight time schedule.

In my report to the Technical Committee entitled "Evidence of Geothermal Potential in Kahauale'a", I presented all the information available to me to support the Developer's contention that a viable geothermal resource exists within the boundaries of Kahauale'a to justify an exploration and development project. Probably the most compelling evidence is the fact that a commercial resource was found in the Lower Rift. Since the Upper Rift is the identical geologic province, the existence of a resource is highly probable. The Statewide Assessment carefully addressed the detailed evidence and arrived at essentially the same conclusion.

Even though there is a high probability of a commercial resource at Kahauale'a, the recent Kilauea eruption at Pu'u O requires further affirmation that drilling and production operations can be conducted safely if hazards are encountered and otherwise with minimum disturbance to the community and natural environment.

III. GEOLOGICAL HAZARDS

A lava flow is the most probable hazard that confronts a geothermal project in the East Rift Zone. Circular C-107 addresses, in some detail, the mitigating measures that are available and that could be employed. The frequency, location, and duration of eruptions are unpredictable such that certain risks are presented. During drilling the developer bears the entire risk. Even in the production phase, private capital can bear the risk wholly or in part since the power plants can be privately financed and owned. The public will only bear a minimum risk no greater than the risk of routine weather related accidents to an electrical distribution system.

Drilling will be conducted with personnel safety and well security as high priorities. The following measures are planned:

1. As a practical matter, I would not advise drilling to be initiated near an active eruption.

2. Modern metallurgy is quite capable of handling situations where lava is encountered on the surface or sub-surface. Wellbore bridge plugs will be available to isolate any productive sub-surface formations if drilling operations must be curtailed. In addition, surface valves and blowout preventers will provide further security. The general practice is to install redundant valves or blowout preventers for reliability. The major supplier of geothermal wellheads and valves is W-K-M. They have stated that the wellheads and valves will not melt even if covered by a lava flow. Experiments by Sandia Laboratories in Kilauea Iki Lava Lake showed that casing can be installed even in molten lava and

that heat exchangers exposed to molten lava withstood the temperatures and gases.

3. Dikes or berms will be constructed where possible to divert a lava flow away from drill sites and power plants. In the Upper Rift Zone the topography has generally a steeper slope than the Lower Rift. As such, lava barriers would probably have better results there than in the Lower Rift Zone. Furthermore, the relative proximity to residential areas in the Lower Rift makes diversions more risky. There are more open lava fields in the Upper Rift where flows can be diverted.

4. Evacuation plans will be maintained and drills conducted to train personnel in proper procedures for an orderly operation.

5. Smaller plants may be utilized to reduce the size of each development and lessen vulnerability to lava flows. Areal diversification is the best protection for the public against disruption of electrical service. Most power plants can operate at higher than name plate ratings such that a 5 MW plant could generate nearly 10 MW. This could compensate for the loss of another power plant. The best illustration is the Occidental Geothermal Plant #1 in The Geysers where a

single turbine can produce twice its rated output by increasing the pressure and flow of steam to the turbine.

IV. GEOTHERMAL TECHNOLOGY

The high cost of geothermal operations has fostered the growth of technology in drilling, power plant design, and environmental protection systems. Industry continues to develop new equipment and skills to improve operating efficiency and safety for all concerned. Two areas, noise and H2S abatement, standout as having made outstanding progress toward responsible operations.

1. NOISE

Disturbance due to noise is a function of distance from the source and sound intensity. Noise levels at the drill site must be maintained below levels that may present a health hazard to rig personnel. The intent is to maintain operations that are in compliance with county noise guidelines. The loudest source of noise is when steam blows from a well without any muffling device. Since all air drilling will be conducted with a cyclone muffler (See Figure 3 in Circular C-108 Geothermal Technology), noise should be under control. In fact, an additional noise abatement technique employed in The Geysers is to pump water into the blooie line. This reduces noise on the order of 10-20 db. During a well test, the well will always be connected to a muffler of some kind. In the event that blowing the well to atmosphere (venting) is the only alternative, then a temporary disturbance may occur in communities surrounding a drill site. The only condition that would force venting to occur would be if, for some reason, the well started to produce a large amount of rock and debris to the extent that plugging of the cyclone muffler or the rock muffler occurred. When such a condition occurs, the severity of the problem must be known, therefore venting is necessary to observe whether the condition is improving (cleaning up), staying the same, or getting worse. This knowledge is necessary in order for the field manager to decide on the proper course of action to correct the problem. Devices known as rock catchers can be installed downstream of the wellhead to remove the rock and prevent them from damaging the rest of the system. These devices must be custom made for the severity of rock problems.

HGP-A gives us an idea of what an operation might be like. Since the power plant started up, HGP-A has never been free vented without a muffler. This record is an important reference point from which to measure noise impacts.

A noise-free operation is highly desired by the worker in a geothermal operation. No one wants to vent a well unless it is absolutely the last resort.

2. H2S ABATEMENT

Control of hydrogen sulphide(H2S) has a high priority in geothermal operations because of its potential hazard to personnel. Therefore, similar incentives to controlling noise apply to controlling H2S. People will not be available to work if the operation is unsafe and unpleasant. It is definitely to the developer's benefit to maintain the areas around power plants, drilling rigs, and wells in a safe, hazard free condition.

The technology for efficient H2S abatement is available in many forms depending on the resource and size of plant. No project can be planned, nor will they be approved, without such technology. In Geothermal Technology(Circular C-108, a statement is made on page 5 that well throttling as a means to reduce H2S emissions, may induce added stress which could damage a well's casing or wellhead. This could happen but is not likely because wells are designed to withstand at least twice the expected pressure at the highest temperature expected. Further, expansion spools are available to allow as much as 4 feet of casing expansion or contraction. This device is widely employed on hot water wells in the Imperial Valley. The ability to throttle and shut-in wells is essential not only for H2S abatement but also for safety reasons. Fears that geothermal wells and power plants will spew poisonous gases is a myth held by the uninformed.

7. CONCLUSION

Geothermal is where it's found. It cannot be developed where desired. Therefore, a system of mutual respect and coexistence is a reasonable compromise that should be attainable. I do not see any reason why geothermal could not be developed in a responsible manner in Hawaii such that the industry and community would be proud of it.

Resume of:

GERALD NIIMI

5721 Brigadoon Way
Santa Rosa, California 95405
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WORK EXPERIENCE

THERMASOURCE, INC. Santa Rosa, California

July 1980 to present: Vice President of Resource Development for geothermal consulting firm. Services to clients include project management, well testing, resource assessments, pressure buildup analysis, and project economics.

THERMOGENICS, INC. Santa Rosa, California

May 1978 to July 1980: Operations Manager responsible for daily steam deliveries to 55 MW geothermal power plant. Coordinator of drilling activities between drilling consultants, field operations and geologists. In charge of general administration of home office including cash flow performance, procurement, personnel administration, and regulatory compliance. Prior to that held position of Chief Reservoir Engineer. Duties included estimation of steam reserves, projection of well productivities, well testing and recommendation of capital investments to maintain steam supply. Advised management on matters pertaining to joint ventures and property acquisitions. Promoted to Operations Manager in August 1979.

EXXON COMPANY U.S.A. Houston, Texas
August 1968 to May 1978
1974-1978: Senior supervising engineer in Western Division Office, Los Angeles, California. Responsible for planning the development of Hondo Field in Santa Ynez Unit. Duties included selection of drilling locations, completion intervals, and updating reservoir description. Also represented company in technical meetings during unitization of Prudhoe Bay Field. Work involved detailed calculations of oil-in-place using well logs and cores. Advised Exploration Department on prospect evaluation and economics for competitive lease sales in Gulf of Alaska and Lower Cook Inlet. Other activities included technical reviews of projects recommended by District engineers, conducting seminars on economics and investment evaluation, and supervising Division computer operations.

1972 to 1974: Staff engineer in Kingsville District, South Texas. Responsible for reservoir surveillance and management of several fields and about 500 wells. Prepared workover and drilling recommendations and initiated capital projects such as compressor installations. Experience in oil and gas production operations, waterflood projects, and gas injection and cycling projects. Completed major field oil and gas depletion studies and reserve estimates. Promoted to Supervising engineer in 1973. Transferred to Los Angeles in 1974.

1968 to 1972: Engineer in Western Division Office, Los Angeles. Responsible for development of subsea electrical connectors for deepwater oil production system. Later assigned to Planning Group charged with assessing facility, manpower, and permitting requirements for development of various offshore prospects. Performed detailed study of Monterey Chert reservoir in Santa Ynez Unit using computer simulation. Results of studies led to installation of 850' platform in Santa Barbara Channel.

EDUCATION

Purdue University, 1965. B.S. in Electrical Engineering. Eta Kappa Nu Honorary Electrical Engineering Fraternity.

Post graduate work in Business Administration at University of Southern California, 1969 to 1972.

Attended Exxon's Reservoir Engineering School, Effective Supervision School, Advanced Management Seminar, Basic Geology and Well Logging School, and Well Testing Seminar.

MILITARY SERVICE

USNR (Civil Engineer Corps), 1965-1968. Attained rank of Lieutenant. Attached to NAS Lemoore 1965-1967 as Contracts Administrator for Navy construction projects and service contracts. Attached to NAF Cam Ranh Bay, Republic of Viet Nam, 1967-1968 as Public Works Officer. Command of 30 man organization performing construction and maintenance functions. Resigned commission in 1970.

PROFESSIONAL MEMBERSHIP

SPE of AIME Golden Gate Chapter.
Geothermal Resources Council.
Registered Petroleum Engineer (California).

PERSONAL DATA

Born:	November 16, 1943 at Kahuku, Hawaii.
Married:	1969. Wife a former elementary school teacher. One child.
Health:	Excellent.
Hobbies:	TV and radio repair, golf, gardening, horseman.

TESTIMONY OF CHARLES H. LAMOUREUX
FOR CONTESTED CASE HEARING

1. INTRODUCTION

My name is Charles H. Lamoureux. I am a professor of botany at the University of Hawaii at Manoa, where I have been employed as a faculty member since 1959. I mention this merely to establish my credentials since I am speaking today simply as a professional botanist; I am not representing the University of Hawaii nor the State of Hawaii. I hold a Bachelor of Science degree in botany from the University of Rhode Island, a Master of Science degree in Botany from the University of Hawaii, and a Doctor of Philosophy degree in Botany from the University of California at Davis. Since 1953 I have been actively involved in the study of Hawaiian botany and have conducted botanical field studies here. Since 1980 my research has centered especially on the study of Hawaiian ferns. The details of my experience, qualification and scientific publications are included in the curriculum vitae attached to this statement.

My familiarity with the botany of the proposed Kilauea Upper East Rift Zone (Kahauale'a) Geothermal Resource Subzone is based on a number of visits to nearby areas of the Kilauea Upper East Rift Zone between 1954 and

1976; on four days of fieldwork in the proposed Subzone itself in 1981 and 1982 (in connection with preparation of part of the environmental assessment for CDUA No. HA-3/2/82-1463); and on three more days of field work in and adjacent to the proposed subzone on December 1-3, 1984, just before the last phase of the Pu'u O eruption.

2. ADENOPHORUS PERIENS: AN UPDATE

In Kahauale'a and vicinity is the only known remaining large population of the endemic Hawaiian fern *Adenophorus periens*. (A small population of less than 100 plants, has recently been discovered on Molokai). This plant has been proposed for listing as an endangered species under Federal law, and is currently under review.

The record of *In re the CDUA of the Estate of James Campbell* (CDUA No. HA-3/2/82-1463) incorporates the testimony I presented on the distribution, ecology, and potential effects on this fern of proposed geothermal development at Kahauale'a. Today I wish to update that information based on recent studies of the status of the plant, after nearly two years of nearby volcanic eruptions, and a period of pronounced drought in the area.

The effects of recent volcanic eruptions have been of three types:

(a) some forest areas supporting the fern have been covered by lava flows originating from the Pu'u O vent;

(b) other forest areas have been impacted by tephra (cinder) fallout, associated with fountaining from the same vent; and

(c) the forest areas impacted by tephra, and additional forest areas, have been adversely affected by volcanic fumes.

In previous testimony estimated population size of _Adenophorus periens_ was based on 6500 acres of forest in Kahauale'a of the type supporting 10 or more plants of the fern per acre. Recent lava flows have covered only a small part of this area. (The flows may have covered some additional fern habitat in the Wao Kele O Puna Natural Area Reserve, but this area was not included originally in estimating population size).

The tephra and volcanic fumes associated with eruptions from Pu'u O seem to have had a more severe effect on _Adenophorus periens_ than have the lava flows. At one site about 1.5 miles NW of Pu'u O which we sampled on December 2, 1984, 50 of 51 _Adenophorus periens_ plants appeared to be dead. This was in an area with about 2 inches of recently deposited tephra on top of the soil, pieces of the volcanic materials were still present on the tips of tree fern stems and in the crotches of tree branches, and many of the plants here showed scorched or burned areas where the falling tephra had touched them.

Further from the vent the damage was less severe. For example, at a site about four miles N of Pu'u O, near the end of Captain's Drive, which we sampled on December 3, 1984, 57 of 100 plants were alive and apparently thriving, while 43 appeared to be dead. In this area there was no evidence of any recently deposited tephra.

While the tephra was obviously one source of damage at the first site, in both sampled sites it is probable that some of the damage observed resulted from the presence of volcanic fumes and some resulted from the rather severe drought which has recently occurred in the area. It was not possible to separate precisely the effects of the drought from those of the volcanic fumes. However, the effects of the drought would be expected to be similar throughout the area, while the volcanic fumes would be expected to be more severe closer to the vent.

There is no previous work on Adenophorus periens which would facilitate accurate prediction of what sort of recovery is likely to occur. Some other ferns in the areas have already started to recover, probably as a consequence of recent higher rainfall; some, including Adenophorus periens, are not yet showing significant recovery, but they may well do so with continued wet conditions. The recovery rates and extents of most species would seem to be related primarily to rainfall, and it is also possible that the original damage from fumes and from cinders might well have been less pronounced had the plants not been suffering from drought at the time of the eruptions.

Given that there had not been eruptions of this magnitude in the Kahauale'a area for at least 200 years, I would suggest that the *Adenophorus periens* population in the area could eventually build up to its pre-eruption status again, although it might take several decades, or even a century or two to happen.

3. RELATIONSHIP BETWEEN CURRENT STATUS OF *ADENOPHORUS PERIENS* AND POSSIBLE GEOTHERMAL DEVELOPMENT IN THE PROPOSED SUBZONE

In comparison with conditions prior to the Pu'u O eruptions, the population of *Adenophorus periens* in the proposed Geothermal Resource Subzone is considerably lower today, and the activities associated with geothermal site development would probably result in direct damage to fewer plants of *Adenophorus periens* than was previously the case. Site development could interfere with recovery of the species, but the risks involved here are difficult to evaluate when the course of recovery is still uncertain. In any case, it is unlikely that interference with recovery would have any more significant effects on *Adenophorus* *periens* than the project would have if it had been carried out under the conditions existing in the area before the recent eruptions.

The best remaining area of *Adenophorus periens* is now located outside and north of the proposed Geothermal Resource Subzone. It could probably be further protected by inclusion of some sort of sanctuary.

Of the four factors responsible for the recent decline of *Adenophorus periens*, lava flows, tephra deposits, emission of volcanic fumes and drought, the only one which might be affected in any way by geothermal development would be the emission of fumes from geothermal wells and power plants. It seems reasonable to assume that any air quality standards which have been or will be adopted will assure that quantities of emissions from geothermal development will be well below the amounts released during eruptions, and probably below the amounts necessary to cause damage to the native flora in the area. If such is the case, then the risks to the the flora associated wth geothermal development are no greater than they were at the time of the previous contested case hearing, and if the mitigation measures proposed then are adopted, the prospects for the long-term survival of *Adenophorus periens* should not be significantly different than they were then.

CURRICULUM VITAE

CHARLES H. LAMOUREUX 039-22-1029

Born: September 14, 1933; West Greenwich, Rhode Island
Married, two children

Degrees: B.S., Botany, Univ. of Rhode Island, 1953; M.S., Botany, Univ. of Hawaii, 1955; Ph.D., Botany, Univ. of California at Davis, 1961

Professional Experience:

Graduate Assistant in Botany, Univ. of Hawaii, 1953-55
Junior Plant Pathologist, California Dept. of Agriculture, Summer 1955
Graduate Assistant in Botany, Univ. of California at Davis, 1955-59
Assistant Professor of Botany, Univ. of Hawaii, 1959-64
Associate Professor of Botany, Univ. of Hawaii, 1964-71;
Professor of Botany, Univ. of Hawaii, 1971-present

Other Professional Experience:

Visiting Assistant Professor, Univ. of British Columbia, Summer 1963
Visiting Colleague, Dept. of Botany, Canterbury Univ., Christchurch, New Zealand, 1965-66
Guest Scientist, National Biological Institute of Indonesia, Bogor, 1972-73, 1979-80
Director, National Science Foundation Summer Institute in Science and Mathematics for Teachers of U.S. Children in the Far East, conducted at Chofu, Japan. Summers of 1968 through 1971, (Faculty member in this Institute, summers of 1964, 1965, 1967)
Faculty member, NSF Summer Institute in Science and Mathematics for teachers in American Samoa, Summer 1965
Chairman, Dept. of Botany, Univ. of Hawaii, 1962-65
Acting Chairman, Dept. of Botany, Univ. of Hawaii, 1976-78
Acting Associate Dean for Curriculum, College of Arts and Sciences, Univ. of Hawaii, 1976-77
Project Coordinator, Instructional Assistance Unit, University of Hawaii, 1977-79
Research Associate in Botany, Bernice P. Bishop Museum, 1963-present
Botanist, H. L. Lyon Arboretum, 1968-present
Member, Scientific Advisory Committee, Pacific Tropical Botanical Garden, 1967-present

Membership in many professional societies including:

American Association for the Advancement of Science (Fellow)
International Association for Plant Taxonomy
Botanical Society of America (Member, Committee on Conservation)
Sigma Xi scientific research society

EXHIBIT "A"

Community Service of Professional Nature:

Member, Advisory Committee on Plants and Animals, Quarantine Branch, State Department of Agriculture, 1973-present
Member, Technical Committee on Endangered Hawaiian Plants, State Division of Forestry, 1976-present
Hawaiian Botanical Society (past President, Vice-President, Secretary, Treasurer, Newsletter Editor)
Conservation Council for Hawaii (past Member, State Board of Directors)
Hawaiian Botanical Gardens Foundation (past Member, Board of Trustees; First Vice-President)
Hawaii Audubon Society (President - 1982)

Teaching duties have included the following courses: Natural History of the Hawaiian Islands; The Hawaiian Environment; Plant Anatomy; Morphology of Vascular Plants; Seminars in Plant Morphology; Plant Microtechnique; General Botany; General Biology; Identification of Tropical Plants; courses in biology to update high school biology teachers.

Graduate student advising: Have chaired graduate committees for 9 PhD and several MS students who have completed degrees, and have served on many other graduate student committees. Have served as external examiner for PhD candidates at the Univ. of Singapore and Canterbury University.

Research grants and contracts have been received from: National Science Foundation; National Institutes of Health; National Park Service, U. S. State Department

Field work has been conducted in: Hawaii (including Leeward Islands); American Samoa, New Zealand, Japan, northeastern U.S., western U.S. and Canada, Indonesia (Borneo, Java, Bali, Moluccas, Sumatra, Timor), Micronesia

LIST OF PUBLICATIONS - CHARLES H. LAMOUREUX

SCIENTIFIC PAPERS

Lamoureux, C. H. 1954. Proposed amendments to the International Code of Botanical Nomenclature. Proposals No. 84 and 85. Taxon 3:19.

Gifford, E. M., Jr., W. B. Hewitt, A. D. Graham, & C. H. Lamoureux. 1956. An internal symptom for identifying fanleaf in the grapevine. California Dept. of Agr. Bull. 45: 268-272.

Lamoureux, C. H. 1961. Plants of Paiko Lagoon. Elepaio 21:51-52.

Lamoureux, C. H. 1961. Botanical observations on Leeward Hawaiian atolls. I. Notes on the plants of Kure Atoll. II. Vascular plants of Tern Island, French Frigate Shoal. Atoll Research Bull. 79:1-10.

Lamoureux, C. H. 1963. Additional plants from the Midway Islands. Pacific Science 17:374.

Plucknett, D. L., J. C. Moomaw, & C. H. Lamoureux. 1963. Root development in aluminous Hawaiian soils. Pacific Science 17:398-406.

Lamoureux, C. H. 1963. The flora and vegetation of Laysan Island. Atoll Research Bull. 97:1-14, 3 pl.

Doty, M. S. & C. H. Lamoureux. 1964. Proposals on botanical nomenclature. F. Miscellaneous nomenclatural matters. Taxon 13:18-21.

Lamoureux, C. H. 1964. The Leeward Hawaiian Islands. Hawaiian Bot. Soc. Newsletter 3:7-11.

Miyashita, R. K., H. Y. Nakasone, & C. H. Lamoureux. 1964. Reproductive morphology of acerola (Malpighia glabra L.). Hawaii Agr. Expt. Sta. Tech. Bull. 63:1-31.

Mueller-Dombois, D. & C. H. Lamoureux. 1967. Soil-vegetation relationships in Hawaiian kipukas. Pacific Science 21:286-299.

Lamoureux, C. H. 1968. The vascular plants of Kipahulu Valley, Maui. In: Warner, R. E. (Ed.). Scientific report of the Kipahulu Valley Expedition:23-54. Published by The Nature Conservancy.

Tomich, P. Q., N. Wilson, & C. H. Lamoureux. 1968. Ecological factors on Manana Island, Hawaii. Pacific Science 22:352-368.

Sastrapradja, C. S. & C. H. Lamoureux. 1969. Variations in wood anatomy of Hawaiian Metrosideros (Myrtaceae). Annales Bogorienses 5(1):1-83.

Lamoureux, C. H. 1970. Plants recorded from Kahoolawe. Hawaiian Bot. Soc. Newsletter 9:6-11.

SCIENTIFIC PAPERS (cont'd.)

St. John, H. & C. H. Lamoureux. 1971. Peperomia kipahuluensis St. John and C. Lamoureux, sp. nov. (subgen. Sphaerocarpidium), pp. 43-44 In: St. John, H. Endemic plants of Kipahulu Valley, Maui, Hawaiian Islands. Hawaiian Plant Studies 36. Pacific Science 25: 39-79.

Lamoureux, C. H. 1971. Some botanical observations on koa. Hawaiian Bot. Soc. Newsletter 10:1-7.

Lamoureux, C. H. 1973. Conservation problems in Hawaii. Pp. 315-319 in: Costin, A. B. & R. H. Groves (Eds.). Nature Conservation in the Pacific. Australian National University Press. 337 pp.

Sakai, W. S. & C. H. Lamoureux. 1973. Refractive spherules in phloem of Microsorium scolopendrium and Psilotum nudum. Protoplasma 77: 221-229.

Lamoureux, C. H. 1973. Plants. Pp. 63-66 in: R. W. Armstrong (Ed.). Atlas of Hawaii. Univ. Press of Hawaii. 222 pp.

Lamoureux, C. H. & J. Arditti. 1973. Orchids at Kebun Raya. American Orchid Society Bulletin 42: 969-971.

Lamoureux, C. H. 1974. Observations on conservation in Indonesia. pp. 116-121 in: K. Kartawinata and R. Atmawidjaja (Eds.), Symposium on coordinated stuy of lowland forests in Indonesia. SEAMEO Regional Center for Tropical Biology (BIOTROP) and Faculty of Forestry, Bogor Agricultural University, Bogor, Indonesia.

Lamoureux, C. H. & Suhirman Djirman. 1974. Report on the Rumphius Expedition I. 7. Observations on the flora and vegetation of southern Maluku. Oseanologi di Indonesia 1974, No. 1: 46-60.

Lamoureux, C. H. 1975. Phenology and floral biology of Monodora myristica (Annonaceae) in Bogor, Indonesia. Annales Bogorienses 6: 1-25.

Lamoureux, C. H. 1975. Phloem tissue in angiosperms and gymnosperms. pp. 1-20 in: S. Aronoff, et al, (Eds). Phloem Transport. NATO Advanced Study Institutes Series: Ser. A., life sciences, vol. 4. x + 636 pp.

Lamoureux, C. H. 1975. Tropical forests in South East Asia: genetic resources for plants other than timber. pp. 213-216 in: J. T. Williams, C. H. Lamoureux, and N. Wulijarni-Soetjipto (Eds.). South East Asian Plant Genetic Resources. 272 pp. International Board for Plant Genetic Resources, SEAMEO Regional Center for Tropical Biology/BIOTROP, Badan Penelitian dan Pengembangan Pertanian, and Lembaga Biologi Nasional - LIPI. Bogor, Indonesia

SCIENTIFIC PAPERS (cont'd)

Lamoureux, C. H. 1976. Endangered plants in Hawaii Volcanoes National Park. Pp. 123-125 in: C. W. Smith (Ed.), Proceedings, First Conference in Natural Sciences, Hawaii Volcanoes National Park. Cooperative National Park Resources Studies Unit, Department of Botany, Univ. of Hawaii at Manoa.

Lamoureux, C. H. 1978. The scientific significance of Cook's third voyage. Pp. 65-74 in J. N. Hurd & M. Kodama (Eds.), Captain Cook and the Pacific Islands. Misc. Work Papers (1978:3), Pacific Islands Program, University of Hawaii.

Lamoureux, C. H., D. Mueller-Dombois, and K. W. Bridges. 1981. Section on "Trees" in chapter on "Temporal Variation of Organism Groups Studied". Pp. 391-407 in: D. Mueller-Dombois, K. W. Bridges, and H. L. Carson (Eds.), Island Ecosystems: Biological Organization in Selected Hawaiian Communities. US/IBP Synthesis Series 15. 583 pp.

BOOK

Lamoureux, C. H. 1976. Trailside plants of Hawaii's National Parks. Hawaii Natural History Association. 80 pp. Revised edition, 1982.

(Note: won U.S. National Park Service Director's Award for professionalism in publication, and The National Parks Cooperative Association Award of Excellence for best colored book-length publication for 1977-78.)

BOOKS EDITED:

Williams, J. T., C. H. Lamoureux, and N. Wulijarni-Soetjipto (Editors). 1975. South East Asian Plant Genetic Resources. International Board for Plant Genetic Resources, SEAMEO Regional Center for Tropical Biology/ BIOTROP, Badan Penelitian dan Pengembangan Pertanian, and Lembaga Biologi Nasional-LIPI. Bogor, Indonesia. 272 pp.

Lamoureux, C. H. (Editor). 1978. Pacific Science Association. Proceedings, Third Inter-Congress, July 18-22, 1977, Bali, Indonesia. Indonesian Institute of Sciences, Jakarta, vii + 477 pp.

Lamoureux, C. H. (Editor of English Translation). 1980. Fruits. International Board of Plant Genetic Resources, Rome, 127 pp. (Translation of S. Sastrapradja (Editor). 1977. Buah-buahan. LIPI, Bogor).

TECHNICAL REPORTS

Mueller-Dombois, D. & C. H. Lamoureux. 1966. Kipukas and soil relations. In Doty, M. S. & D. Mueller-Dombois: Atlas for bioecology studies in Hawaii Volcanoes National Park. Hawaii Botanical Science Paper #2: 285-314.

Fosberg, F. R. & C. H. Lamoureux. 1966. Vegetational responses to volcanic activity in the Chain-of-Craters area. In Doty, M. S. & D. Mueller-Dombois: Atlas for bioecology studies in Hawaii Volcanoes National Park. Hawaii Botanical Science Paper #2: 315-329.

Siegel, S. M. & C. H. Lamoureux. 1968. Role of gravitational stress in land plant evolution: the gravitational factor in lignification. Hawaii Botanical Science Paper #7: 1-58.

Lamoureux, C. H. 1968. Vascular plants. In Doty, M. S. Biological and physical features of Kealakekua Bay, Hawaii. Hawaii Botanical Science Paper #8: 194-207.

Lamoureux, C. H. 1972. Guide to Mauna Kapu - Palikea Trail. Pp. 111-115. In: Fosberg, F. R. Field Guide to Excursion II. Tenth Pacific Science Congress. Revised Edition. University of Hawaii. 249 pp.

Lamoureux, C. H. 1973. Phenology and growth of Hawaiian plants, a preliminary report. Technical Report No. 24, Island Ecosystems Integrated Research Program, U. S. International Biological Program. Univ. of Hawaii. 62 pp.

Lamoureux, C. H. & L. Stemmermann. 1976. Kipahulu Expedition 1976. Tech. Rept. No. 11, Cooperative National Park Resources Studies Unit, Department of Botany, Univ. of Hawaii at Manoa. 12 pp.

Lamoureux, C. H. 1979. Evaluation of rare and endangered bird research programs for Hawaii's national parks. Tech. Rept. No. 23, Cooperative National Park Resources Studies Unit, Department of Botany, Univ. of Hawaii at Manoa. 33 pp.

Abbott, A. T., E. A. Kay, C. H. Lamoureux, and W. L. Theobald. 1981. Natural Landmarks Survey of the Hawaiian Islands, prepared for the National Park Service Natural Landmarks Program, Department of the Interior. Depts. of Botany and Zoology, University of Hawaii at Manoa. 230 pp.

NEWSLETTER ARTICLES OF PROFESSIONAL NATURE

Lamoureux, C. H. 1963. A Hawaiian botanical garden. Hawaiian Bot. Soc. Newsletter 2: 74-75.

Lamoureux, C. H. 1963. Field guide to Mauna Kapu - Palikea Trail. Hawaiian Bot. Soc. Newsletter 2: 81-83.

Lamoureux, C. H. 1963. George Campbell Munro. Hawaiian Bot. Soc. Newsletter 2: 131-134.

Lamoureux, C. H. 1968. Kipahulu Valley. Hawaiian Bot. Soc. Newletter 7: 9-1[illegible].

NEWSLETTER ARTICLES OF PROFESSIONAL NATURE (cont'd.)

Lamoureux, C. H. 1968. Should the axis deer be introduced to the island of Hawaii? Elepaio 29: 10-15.

Lamoureux, C. H. 1969. Field guide for the Hawaiian Botanical Society foray - July 4, 1969. Hawaiian Bot. Soc. Newsletter 8: 26-27.

Lamoureux, C. H. 1971. Twelfth Pacific Science Congress, General Report. Hawaiian Bot. Soc. Newsletter 10: 43-44.

Lamoureux, C. H. 1973. A botanical expedition to South Kalimantan. Bulletin Kebun Raya 1: 11.

Lamoureux, C. H. 1973. Ekspedisi botani ke Kalimantan Selatan. Buletin Kebun Raya 1: 12. (Indonesian language translation of above).

Lamoureux, C. H. 1975. Report on the Thirteenth Pacific Science Congress. Hawaiian Bot. Soc. Newletter 14: 85-89.

Lamoureux, C. H. 1976. Response to T. K. Tagawa's address "Endangered species in Hawaii - effect on other resource management". Hawaiian Bot. Soc. Newsletter 15: 14-21.

REVIEWS AND ANNOTATED BIBLIOGRAPHIES

Lamoureux, C. H. 1968. Review of: "Tropical Plant Types" by B. G. M. Jamieson and J. F. Reynolds. Quarterly REv. Biol. 43: 202.

Lamoureux, C. H. 1975. Recent Pacific Publications - 1. Hawaiian Bot. Soc. Newsletter 14: 26-31.

Lamoureux, C. H. 1975. Recent Pacific Publications - 2. Hawaiian Bot. Soc. Newsletter 14: 69-78.

Lamoureux, C. H. 1976. Recent Pacific Publications - 3. Hawaiian Bot. Soc. Newsletter 15: 37-53.

Lamoureux, C. H. and W. J. Hoe. 1978. Recent Pacific Publications--4. Hawaiian Bot. Soc. Newsletter 17: 69-77.

ABSTRACTS

Lamoureux, C. H., M. H. Bell, & D. Gould. 1954. Stelar morphology of Hawaiian Pteridophytes. (Abstract). Hawaiian Academy of Science, Proc., 1953-1954: 12-13.

Lamoureux, C. H. 1963. Vegetation of Laysan. (Abstract). Hawaiian Academy of Science, Proc., 1961-1962: 22.

Lamoureux, C. H. 1973. A comparison of human influences and protection status of ecological reserves in Indonesia and Hawaii. (Abstract). P. 42 in: Mueller-Dombois, D. Natural area system development for the Pacific region, a concept and symposium. Technical Report No. 26, Island Ecosystems Integrated Research Program, U. S. International Biological Program. Univ. of Hawaii. 55 pp.

Lamoureux, C. H. 1976. Phenological Studies in Hawaii Volcanoes National Park. (Abstract). p. 127 in: C. W. Smith (Ed.), Proceedings, First Conference in Natural Sciences, Hawaii Volcanoes National Park, Cooperative National Park Resources Studies Unit, Department of Botany, Univ. of Hawaii at Manoa.

Lamoureux, C. H. 1978. Hawaii IBP Synthesis: 7. Impact of exotic plants and animals in Hawai'i. (Abstract). p. 198 in: C. W. Smith (Ed.), Proceedings, Second Conference in Natural Sciences, Hawaii Volcanoes National Park, Cooperative National Park Resources Studies Unit, Department of Botany, Univ. of Hawaii at Manoa.

Lamoureux, C. H. 1982. The fern genus Nephrolepis in Hawai'i. (Abstract). In: Fourth Conference in Natural Sciences, Hawaii Volcanoes National Park.

BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Conservation District Use Application of the ESTATE OF JAMES CAMPBELL and TRUE/MID-PACIFIC GEOTHERMAL VENTURE To Permit Exploration and the Development of Geothermal Resources within approximately 8,447.2 Acres of Conservation District Lands at the Kilauea Middle East Rift Geothermal Resource Subzone.	CDUA NO. HA 12/20/85-1830

PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

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PROPOSED FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

1. BACKGROUND

A. Subject

a. This matter involves a Conservation District Use Application to explore for and develop geothermal resources as a permitted use in approximately 8,447.2 acres of the Kilauea Middle East Rift Zone, Puna, Hawaii, which were designated as a Geothermal Resource Subzone by the Decision and Order of the Board of Land and Natural Resources ("BLNR") rendered on December 20, 1985, pursuant to Hawaii Revised Statutes, Section 205-5.2.

B. Description of Area

a. The Kilauea Middle East Rift Geothermal Resource Subzone (KMERZ/GRS) consists of approximately 8,447.2 acres in and adjacent to the Wao Kele O Puna Natural Area Reserve, Hawaii (TMKs: 1-2-08:08, 11-17; 1-2-10:1, 3; 1-5-01:10-13, 40-48, 52, 55).

C. Jurisdiction of the Board of Land and Natural Resources

a. Section 205-5.1(d), Hawaii Revised Statutes, gives the Board of Land and Natural Resources jurisdiction over geothermal activities proposed within a conservation district. Section 205-5.1(d) reads:

> (d) If geothermal development activities are proposed within a conservation district, then, after receipt of a properly filed and completed application, the board of land and natural resources shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether, pursuant to board regulations, a conservation district use permit shall be granted to authorize the geothermal development activities described in the application.

2. CHRONOLOGY - FINDINGS OF FACT ON PROCEDURAL HISTORY:

a. On March 2, 1982, the Estate of James Campbell ("Campbell") filed with the BLNR, a Conservation District Use Application (CDUA) to develop geothermal resources at Kahauale'a, Hawaii.

b. On May 6, 1982, Campbell filed with the BLNR and the Environmental Quality Commission a Draft Environmental Impact Statement in support of its CDUA.

c. On May 20, 1982, the BLNR announced that the CDUA would be conducted as a contested case hearing.

d. On October 25 through 29, 1982, November 15 through 19, 1982, and December 7, through 10, 1982, the BLNR conducted quasi-judicial "contested case" proceedings regarding the CDUA pursuant to the Hawaii Administrative Procedure Act, Chapter 91, HRS, and the BLNR's Rules of Practice and Procedure. The Volcano Community Association ("VCA") was a party to said proceeding.

e. The BLNR by its Findings Of Fact and Conclusions Of Law and Decision and Order dated February 25, 1982, granted Campbell specific exploration rights on the Kahauale'a parcel under CDUA No. HA 3/2/82-1463.

f. Subsequent to the rendering of the Decision referenced above, the Hawaii State Legislature passed Act 296, SLH 198, delegating the Board of Land and Natural Resources the responsibility for designating geothermal resource subzones and selecting those areas that can best demonstrate an acceptable balance among the criteria set forth in said Act.

g. The designation of geothermal resource subzone areas would only be the first step of a two-step process.

After the designation of a geothermal resource subzone, any person who wished to build a geothermal project at a specific site would, as a second step, apply to the BLNR or the appropriate county agency for authority to develop a specific project at a specific site. This second step would be conducted as a contested case if a request for such a hearing was made.

h. Pursuant to Act 296, SLH 1983, the Chairperson of the BLNR assigned the task of recommending geothermal resource subzone areas to the Division of Water and Land Development (DOWALD), State of Hawaii.

i. DOWALD began work on the subzone process after June 14, 1983, when Governor Ariyoshi signed Act 296, SLH 183 into law.

j. A Plan Of Study was devised by DOWALD as an outline by which to assess the various potential areas in view of the criteria specified in Act 296. The principle elements of this strategy included a literature review of available information, and an assessment of the following factors:

* Potential geothermal energy production
* Use of geothermal energy in the area
* Geologic Hazards
* Social and Environmental Impacts
* Compatability with present and planned use

* Potential economic benefits

* Compatability with conservation principles where a subzone falls within a conservation district

k. The 1984 Legislature enacted Act 511, which in part gave first priority to the assessment of Kahauale'a as a geothermal resource subzone. The BLNR was required to act on said designation by December 31, 1984.

l. Included in the designation process was a public information and participation effort to elicit community concerns. Included in this process was a meeting held on July 11, 1984, in the Volcano Community on the Big Island.

m. At that public hearing requests for a contested case hearing on the designation of 5,300 acres of Kahauale'a, Puna, Hawaii, as a GRS were made to the BLNR.

n. Pursuant to these requests, the BLNR under their discretionary power, decided to hold a contested case hearing, reserving the right to litigate at a later time, the issue of whether it was mandatory or not to hold a contested case hearing for the designation of geothermal resource subzones.

o. On December 12, 13, 15, 16, 18, 19, the BLNR conducted quasi-judicial "contested case" proceedings regarding the designation of 5,300 acres of Kahauale'a, Puna, Hawaii, as a geothermal resource subzone pursuant to the Hawaii Administrative Procedure Act, Chapter 91, HRS, and the BLNR's Rules of Practice and Procedure. All intervening parties were given the opportunity to present witnesses and evidence, cross-examine witnesses and present rebuttal evidence.

p. On December 28, 1984, the BLNR issued its Decision and Order on the Proposed Geothermal Resource Subzone at Kahauale'a, Hawaii.

q. In part, the Decision and Order stated that the State of Hawaii formally requested that "the Estate of James Campbell investigate and consider a land exchange involving State owned land in Kilauea Middle East Rift Zone and Campbell Estate's lands at Kahauale'a (Excluding Tract 22) . . . ."

r. The Decision and Order also stated: "The Board of Land and Natural Resources on its own motion hereby directs the Division of Water and Land Development (DOWALD) of the Department of Land and Natural Resources (DLNR) to immediately undertake and conduct an assessment of the Kilauea middle east rift zone in and adjacent to the Natural Area Reserve beginning on the western boundary of the Kamaili geothermal subzone as a potential geothermal resource subzone. Although this area had not previously been evaluated due to its classification as a Natural Area

Reserve, the Board now believes that the area should be reviewed.

If (a) the assessment of the Kilauea middle east rift zone does not result in a designation as a geothermal resource subzone in this area; or (b) a land exchange between the State of Hawaii and the Estate of James Campbell is not consummated then the remainder of the 5300 acres proposed by DOWALD as a geothermal resource subzone in Kahauale'a heretofore not designated by this Decision and Order shall be and is hereby ordered to be so designated as a geothermal resource subzone."

s. Pursuant to the Decision and Order, DOWALD, on its own, held four (4) public information meetings. The dates and places of these meetings are listed below:

March 13, 1985	-	Keeau, Hawaii
March 14, 1985	-	Pahala, Hawaii
May 15, 1985	-	Pahoa, Hawaii
May 16, 1985	-	Pahala, Hawaii

t. The BLNR held a public hearing on September 26, 1985, to elicit community concerns.

u. At the last public hearing, requests for a contested case hearing on the designation of approximately 11,745 acres at the Kilauea Middle East Rift Zone were made.

v. On October 16, 1985, the BLNR announced that a contested case hearing would be held on November 13, 1985, concerning the designation of approximately 11,745 acres in and adjacent to Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve.

w. On November 1, 1985, a prehearing conference was held at the DOWALD conference room in Honolulu, Hawaii. At that time, DOWALD, Mae Evelyn Mull, Karl and Melissa Kirkendall, Frederick Warshauer, John L. Perriera, Susan Carey, Diane Ley, Volcano Community Association, Lehua Lopez, Eva Lee, Louis Whiteaker, Chiu, Leong, Virginia B. MacDonald, Debra Hopson, Ann Markham, Mike Markham, Beverly MacCallum, Matt Luera, Hawaii Audubon Society and Sierra Club, Hawaii Chapter, were admitted as parties to the contested case, while the Estate of James Campbell and the True/Mid-Pacific Geothermal Venture were admitted as intervenors. The intervention status of Palikapu Dedman and Dr. Emmet Aluli were still under consideration by the BLNR.

x. On November 7, 1985, a second prehearing conference was held at the DOWALD conference room. At that time, the Estate of James Campbell and the True/Mid-Pacific Venture continued its objection on the necessity of having a contested case hearing held for the subzone designation process. The Motion was denied on the same grounds, with the understanding that this hearing was being held pursuant to the discretionary authority of the BLNR with the further understanding that the denial does not constitute a decision by the BLNR and that the contested case hearing is required.

y. On November 13, 1985, Palikapu Dedman and Dr. Emmet Aluli were granted intervenor status in the hearing.

z. On November 13, 14, and 15, 1985, the BLNR conducted quasi-judicial "contested case" proceedings regarding the designation of approximately 11,745 acres in the Kilauea Middle East Rift Zone, Island of Hawaii, as a geothermal resource subzone pursuant to the Hawaii Administrative Procedures Act, Chapter 91, HRS, and the BLNR Rules of Practice and Procedure. All parties and intervenors were given the opportunity to present witnesses and present rebuttal evidence.

aa. On August 20, 1985, the Estate of James Campbell along with the True/Mid-Pacific Geothermal Venture filed with the BLNR, a Conservation District Use Application to explore and develop geothermal resources located in the Kilauea Middle East Rift Zone.

bb. On December 20, 1985, the BLNR issued its Decision and Order which designated approximately 8,447.2 acres located in the Kilauea Middle East Rift Zone as a geothermal resource subzone.

cc. On December 24, 1985, the BLNR announced that a public hearing on the application for a CDUA in the KMERZ/GRS would be held.

dd. At the public hearing held on January 20, 1985, requests were made for a contested case hearing on the application for a CDUA.

ee. On February 6, 1986, the Estate of James Campbell and the True/Mid-Pacific Geothermal Venture filed with the BLNR a Final Supplemental Environmental Impact Statement ("FSEIS") in support of its CDUA.

ff. On February 10, 1986, a prehearing conference was held at the BLNR conference room. At that time it was announced that the following were admitted as parties to the contested case: County of Hawaii; Sierra Club Hawaii; Susan Carey; Debra Hopson; Eva Lee; Chiu Leong; Ann Markham; Mike Markham; Beverly McCallum; Diane Ley; Lehua Lopez; Dr. Emmett Aluli; Palikapu O Kamohoali'i Dedman; Mark Huer; Michael La Plante; Rick Warshauer; Mae Mull; Karl Kirkendall and Melissa Kirkendall.

gg. A second prehearing conference was held on February 13, 1986, at which time the parties were to exchange direct written testimony and exhibits.

hh. On February 17, 18, 19, 20, 21, 22, and 23, 1986 and on March 14, 1986, the BLNR conducted quasi-judicial "contested case" proceedings regarding the application for a CDUA permit by the Estate of James Campbell and the True/Mid-Pacific Geothermal Venture pursuant to the Hawaii Administrative Procedures Act, Chapter 91, Hawaii Revised Statutes, and the BLNR's Rules of Practice and Procedure. All parties were given the opportunity to present witnesses and evidence, cross-examine witnesses and present rebuttal evidence.

3. *PROPOSED FINDINGS OF FACT*

A. Development Plan

1. The scope of the proposed project requested under this application is reduced from an electrical energy production level of 250 MW of electricity to 100 MW. The development plan indicates that between 245-300 acres of the total land parcel of 26,000 acres will be needed for project sites and roads. Development would occur over a period of 8-10 years depending on the rate at which geothermal-generated electricity can be absorbed to replace oil-generated electricity. (Applicant's Exh. 1 pg. 2)

2. Initial exploration efforts in the Kilauea Middle East Rift Zone GRS would be conducted to determine the presence of an economically producible resource. Subsequent exploration would be designed to determine the extent of geothermal reservoirs within the KMERZ/GRS. Development and production would occur as the demand for power for local consumption or for export to Oahu by undersea cable is identified or established. (Applicant's Exh. 1 pg. 2-3).

3. A map showing planned development sites is attached hereto as Applicant's Exhibit "1-A". (Applicant's Exh. 1(a))

B. Potential Geothermal Energy Production

1. A panel of technical experts closely associated with geothermal research in Hawaii was assembled to assist DOWALD staff in identification of areas with the potential for high temperature geothermal resources. (DOWALD, Exh. 6, p. 1; KGS 8/27/84, State Exhibit 2, p. 3).

2. A "high temperature" geothermal resource is defined as one having a temperature greater than 125°C at a depth of less than 3 kilometers. (DOWALD, Exh. 6, p. 5, KGS 8/27/84, State Exhibit 2, p. 3).

3. The panel of experts identified the Kilauea East Rift Zone as an area possessing the necessary qualities for designation as a potential resource area based on:

(i) Three wells that encountered a high temperature resource with one of the three presently producing a geothermal resource;

(ii) Geophysical indicators, mainly aeromagnetic surveys, electrical surveys, microearthquake and self-potential surveys;

(iii) Geologic evidence of recent lava intrusion into the east rift zone;

(iv) Geochemical data;

(v) An aeromagnetic anomoly associated with the rift showing that temperatures in excess of 500^{o}C were present at shallow depths in the rift;

(vi) Resistivity anomolies indicating shallow high temperature ground water; and

(vii) Other available information from public and private services.

(Chuck Testimony, p. 2-9; KGS 8/27/84 State Exh. 2, p. 3)

4. The area of the Kilauea East Rift Zone having a probability of 90% or greater chance of encountering a high temperature geothermal resource is indicated by the 90% contour line on p. 5, State Exh. 2, KMERZ GS 9/26/85-5.

5. The area of the Kilauea East Rift Zone having a probability of 25% or greater chance of encountering a high temperature geothermal resource is indicated by the 25% contour line on p. 5, State Exh. 2, KMERZ GS 9/26/85-5.

6. Between contour lines, probability increases systematically from 25% to 90%. (Vol. 22, p. 56, Dec. 19, 1984; KGS 8/27/84, State Exh. 2, p. 3).

7. According to Dr. Richard Moore's study of the geology and petrology of the Kilauea East Rift Zone indicates that there are three (3) areas that overlie secondary magma chambers and thus, are promising geothermal targets. One is the site of the general area of HGPA,

another is the Kalehua area and the third is around Heiheiahulu which is in the area of the proposed development. (Richard Moore, Vol. XI, p. 3108, CDUA hearing).

8. Half of the development area has a probability of 90% or greater of encountering a resource with temperatures about 125 degrees C, the other half has a 25% to 90% probability of encountering the same source. (Applicant's Exh. 18, p. 5.)

9. There is no doubt that there is abundant heat stored in the rift zone. Resevoir permeability is the biggest uncertainty. Although there are no surface measurements that can be made to indicate permeability, indirect evidence such as microearthquakes, swarms and surface faults are usually reliable indicators and both surface faults and earthquakes have been documented in the area. (Campbell Exh. 1, p. 2-3).

10. Dr. Donald M. Thomas, after reviewing the existing geophysical and geochemical data, concluded that there is a very good probability of a geothermal resource in the Kilauea Middle East Rift Zone. (Testimony of Donald M. Thomas, Vol. VI, February 20, 1986, p. 163.)

11. Dr. Thomas estimates that up to 4,800 megawatts of thermal energy are intruded into the rift on an

annual basis, and that 20-30% of this could come into the Kilauea Middle East Rift Zone. (Testimony of Donald M. Thomas, Vol. VI, February 20, 1986, pp. 163-164.)

12. Dr. Thomas has indicated that at the present time, the rainfall recharge in the upper rift passes parallel to the rift and ultimately exists at lower elevations. Dr. Thomas believes that there is continual circulation of meteoric or rain water that falls on the rift zone and goes down to some depth which is indicated to be more than two kilometers, and is heated and then rises back to the surface. (Testimony of Donald M. Thomas, Vol. VI, February 20, 1986, pp. 172-173.)

C. Use of Geothermal Energy

1. HELCO's Forecast Planning Committee predicts approximately a 2% growth load for the Island of Hawaii for the next 20 years. Based upon this 2% growth load and considering other factors such as the closing of Puna Sugar Company, HELCO must plan for generation additions to meet this increase in growth load for the next 20 years. (Applicant's Exh. 9, p. 2; HA 3/2/82 1463).

2. Forecasted peak demand for the Island of Hawaii for 1986 has already been exceeded. (Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 6).

3. HELCO could use 10 MW of geothermal energy or more in 1989 and 13 MW in 1991, 1993 and 1999, for a total

of more than 49 MW. Therefore, some 49 MW or more of geothermal energy could reduce HELCO's dependency on oil before the end of this century. (Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 6).

4. Recorded sales in 1985 on the Island of Oahu was 5,336 million kilowatt hours (Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 26).

5. Moving ahead with True/Mid-Pacific's proposed project will provide the utilities, the State, and those who may commercialize the undersea cable with information on the cost and economics of geothermal energy. Mr. Williamson testified that if the utilities do not move ahead, and instead construct new generation facilities that use non-renewable, imported fuels, they will lose an opportunity to take a solid step in the direction of energy self-sufficiency. Should the utilities need to develop additional generation capability that requires a standard fossil fuel source, they will have to make an extended commitment to it, and live with their decision for an extended period of time. (Applicant's Exh. 14, p. 2).

6. With respect to planning for Hawaii County's future power requirements, Hawaiian Electric would expect a new plant to have a useful life in excess of 50 years. Thus, the 100MW level requested by True/Mid-Pacific is

appropriate, even though the initial units may make up only a small percentage of the plant's total capacity. (Applicant's Exh. 14, p. 3).

7. One of the Hawaii State Energy Plan's objectives is to accelerate the transition from fossil fuel to an indigenous renewable energy resource by facilitating private sector activities to explore supply options and achieve local commercialization and application of appropriate alternate energy technologies. The proposed project would be consistent with and promote the attainment of this objective. (State Energy Plan, Applicant's Exh. 31, p. 15; CDUA HA 3/2/82-1463).

8. The establishment of the geothermal project is in accord with the goals and objectives of the County of Hawaii. The County's goals for energy are: 1) to strive towards energy self-sufficiency for Hawaii County; and 2) to establish the Big Island as a demonstration community for the development and use of natural energy resources.

To achieve these goals, a number of policies for County actions and/or programs are set forth. These include:

--encouraging the development of alternative energy resources and the expansion of the energy research industry;

--educating the public on new energy technologies;

--fostering attitudes and activities conducive to energy conservation;

--ensuring a proper balance between the development of alternative energy resources and the preservation of environmental fitness;

--striving to assure a sufficient energy supply for present and future demands;

--providing incentives to encourage the use of new energy sources and the promotion of energy conservation;

--seeking public and private funding for research and development of alternative energy resources; and

--coordinating energy research and development efforts of the public and private sectors.

These goals and policies clearly direct the County to explore the potential of natural energy resources in order that the island of Hawaii can strive towards energy self-sufficiency. Geothermal energy is one of the island's indigenous energy resources. The County recognizes that exploration and development of its potential geothermal resources will assist its overall program to develop the array of alternative energy sources on the island of Hawaii. (County Exh. 1, November 15, 1985).

9. Over 80% of the State's demand for electricity is on Oahu which lacks alternative energy resources sufficient to meet its demand. (VCA Exh. 112, preface, KGS 8/27/84).

10. The relationship between the Hawaii Deep Water Cable Program and geothermal development on the island of Hawaii is a symbiotic one. In the absence of planning and

approval for substantial geothermal development on the Big Island, there is limited justification for the cable program. Conversely, the planning for development of geothermal energy in excess of Big Island requirements is dependent on a successful outlook for the cable program. (Applicant's Exh. 15, p. 1).

11. The outlook for the undersea cable project is highly optimistic. Four years into the research program, no obstacles have been encountered which the people who are involved with the program are not confident can be managed successfully. (Applicant's Exh. 15, p. 1).

12. Geothermal energy is the only renewable resource with potential in the near future to provide a significant substitute for fossil fuel in serving baseload electrical demand. The system presently envisioned could supply approximately one-half (1/2) of Oahu's electrical energy requirements by the year 2000. (Applicant's Exh. 15, p. 2).

13. In the absence of either geothermal development for power export or the submarine cable transmission system, the State of Hawaii will remain largely dependent on fossil fuel for the generation of electrical power. Over 80% of electrical energy consumed in the State of Hawaii is consumed on Oahu. (Applicant's Exh. 15, p. 2).

14. The current timetable for the cable calls for laboratory testing beginning in 1986 and completed in 1987. A 6,000 foot length of cable is now being fabricated in Italy for laboratory testing. That fabrication will be complete by July of 1986. Vessel and cable handling equipment control design work will also begin in 1986 and be completed in 1987. The vessel will be outfitted in 1988, and at-sea testing is scheduled for late 1988. The year 1989 will include demobilization of the equipment and comprehensive examination of all information gathered under the program and completion of a final report no later than March of 1990. This schedule is compatable with the coordinated geothermal/commercial cable development timetable included in the Department of Planning and Economic Development's December 1985 report to the Thirteenth State Legislature. (Applicant's Exh. 15, p. 5-6).

15. A highly successful sea cruise was conducted in late October and early November of 1985 to gather high resolution data from the bottom of the Alenuihaha Channel. That cruise showed no insurmountable obstacles and provided guidance for concentrating efforts on a second cruise in 1986, which will provide a definitive alignment for the cable over the most difficult part of the route. (Applicant's Exh. 15, p. 5).

16. The submarine cable research and development effort for the Hawaii Deep Water Cable Program involves the demonstration of or technical feasibility for manufacturing, testing, deploying, retrieving and operating underwater cables to depths of 1900 meters (6300 feet) over rugged bottom terrain. The present research and development program is structured to address each of these challenges in a manner which confirms the important technical parameters while simultaneously assuring maximum technology transfer to the United States' power cable industry. Initial efforts to evaluate cable options which were suitable for the ocean environment between the neighbor islands and Oahu focused on a comprehensive parametric study of alternate cable designs to determine the preferred candidate system. Design criteria for mechanical strength to withstand the high tensions during cable laying at 1900 meters; power ratings for transmission of electric energy over a distance of 253 kilometers (150 miles) underwater; transportation of long lengths of cables from manufacturing plants to site; techniques for joining (splicing) different cable sections together; and various electrical design and construction properties were developed from which each alternate could be evaluated. This process resulted in the selection of a preferred cable during the Spring of 1985. (Applicant's Exh. 16, p. 2-3).

17. The reference cable chosen for further development and testing is known as self-contained oil-filled cable. This cable consists of an aluminum conductor with layers of high quality paper tape wrapped around the conductor for electrical insulation. In order to provide a water-tight seal, a lead alloy sheath is extruded over the conductor and insulation and a layer of plastic corrosion protection is extruded over the lead to prevent corrosive attack by the marine environment. Two layers of flat steel armoring are wrapped around the entire cable core to provide an external strength member, which supports the cable as it is lowered from the ship on the surface to the bottom of the ocean. The selected cable design for the Hawaiian project has an overall diameter of 118 millimeters (4.7 inches) and weighs 37 kilograms per meter (25 pounds per foot) in air. The weight in seawater is 27 kilograms per meter (18 pounds per foot). This cable is filled with a high quality electric grade insulating oil which provides cooling as well as improving the electrical performance. (Applicant's Exh. 16, p. 3).

18. The selection of the self-contained oil-filled cable design concept over other alternatives was based in part on its superior performance in other major submarine cable projects. Recent projects, such as the submarine

cable installed across the Straits of Messina and the crossing to Vancouver Island, have been constructed using this cable system. As with the Hawaii cable, these projects have required long distance submarine cable lengths and high power ratings. These cables can be manufactured and transported in the long lengths required for the Hawaiian project, and only two cables are needed to transmit upwards of 500 megawatts of electric power. The proven reliability, demonstrated service record, required power ratings and superior mechanical performance of the self-contained oil-filled cables were primary factors in selecting this technology for the submarine cable system. (Applicant's Exh. 15, p. 4).

19. The laboratory test program is scheduled to start in October 1986 and will be completed within 12 months. Therefore, the technical feasibility of the submarine cable for the Hawaiian application should be substantially confirmed by October 1987. The ocean engineering aspects of controlling the large mechanical loads of the submarine cable and the ability to achieve an accurate placement of the cable on the bottom are being investigated independently of the cable testing in the laboratory. Current plans call for an at-sea test program to be initiated in early 1988 with conclusion of the sea trials by the end of summer 1988. Planning and conceptual

design work for the at-sea test program are currently under way. At this time, the prognosis for determination of the technical feasiblity of the cable handling equipment by the fourth quarter of 1988 is excellent. Assessing the present research and development program for both cable and ocean handling and positioning equipment, Mr. Garrity would conclude that the deep water cable technology will be ready for commercialization by the beginning of 1989. (Applicant's Exh. 16, p. 4-5).

20. Other issues which are being dealt with in the research and development effort cover the reliability, maintenance and repair of submarine cables for Hawaii. There are some 4,000 kilometers (2500 miles) of submarine cables installed worldwide. Approximately 97% of this total is installed in open sea and 3% in rivers and lakes. A recently completed survey of submarine cable failures revealed that over 80% of the outages could be attributed to external mechanical damage due to ships' anchors grabbing the cable, fishing trawlers dragging across the cable, or seismic activity resulting in cable motion along fault zones. Careful selection and use of appropriate protection measures, such as embedding the cables in shallow water or beach areas, have proven to be effective remedies to minimize the outages due to mechanical damage. A combination

of these steps to reduce mechanical damage is being considered for Hawaii so that the reliability of the submarine cable link will be very high. (Applicant's Exh. 16, p. 5-6).

21. The repair of the Hawaiian submarine cable has been considered in the R&D program. A repair strategy for different areas along the potential cable routes has been developed. Further refinement of this strategy is being pursued at this time and Mr. Garrity expects a final repair plan by Summer of 1986. Based on the failure survey, the average repair time was 37 days. For Hawaii, Mr. Garrity believes that this time can be reduced or at the least meet the average outage duration for repair of the submarine cable. (Applicant's Exh. 16, p. 6).

22. Mr. Garrity's assessment of the status of the present deep water cable R&D program is that they have identified all the technical areas which need development and testing. Mr. Garrity is confident that they can successfully conclude the R&D program to establish the technical feasibility of the cable by the end of 1988, and that commercialization can proceed immediately thereafter. (Applicant's Exh. 16, p. 6).

D. Geologic Hazards

Geothermal resources in the Puna District exist due to the recent volcanic activity in the region. The volcanic activity in essence serves to continually resupply heat to the system. The volcanic activity responsible for the creation of the resource also creates a certain degree of hazard in the form of earthquakes and the risk of volcanic eruptions. The concurrence of these two factors - high probability of geothermal resource and risks in the nature of volcanic activity are common to young geologic areas where geothermal activities are occurring.

1. Lava Flow.

a. Eruptive activity:

(i) Time and location of eruptions cannot be predicted with any degree of certainty (State Exh. 2, p. 38, DOWALD EXH. 12, p. 82, DOWALD EXH. 6, p. B-54, KGS 8/27/84; Moore Testimony, Vol. VI, December 19, 1984, p. 258).

(ii) The upper East Rift Zone is more subject to lava inundation than is the lower rift zone. (Moore testimony, Vol. VI, December 19, 1984, p. 281; KGS 8/27/84).

b. Characteristics of Hawaiian lava flows:

(i) Flows freely in predictable course dictated by ground slope (DOWALD EXH. 12, p. 1; KGS 8/27/84).

(ii) Lavas are liquid and, therefore, will behave like a liquid. Lavas always tend to flow directly down the steepest available slope and to follow the path of least resistance (Campbell Exh. 6, p. 269; KGS 8/27/84).

(iii) Liquid lava has a specific gravity probability 2 to 2.5 times that of water (Campbell Ex. 6, p. 270; KGS 8/27/84).

(iv) Most flows are thin, 1-5 m. in thickness. Flows will accumulate over previous flows (DOWALD EXH 12, p. 1; KGS 8/27/84).

(v) Duration of flows have averaged 60 days with many lasting 1 day and some such as Mauna Ulu and Pu'u O lasting over a year (DOWALD EXH 12, p. 2; KGS 8/27/84).

(vi) Lava flows are most likely to emanate from vents and fissures located in the central part of the rift zone (i.e., between 90% probability line) (DOWALD EXH. 12, p. 18; KGS 8/27/84).

c. All flows, including current Pu'u O eruption, eventually end (Moore Testimony, Vol. VI, December 19, 1985, p. 2; KGS 8/27/840.

d. The entire Kilauea East Rift is vulnerable to inundation (Helsley Campbell Exh. 1, p. 2; KGS 12/23/84).

e. Mitigation measures are available.

(i) Depending on resource location, siting facilities, including wells away and upslope from the center of the rift zone will mitigate damage to facilities from flows. (Moore Testimony, Vol. VI, December 19, 1985, p.

234; KGS 8/27/84; Niimi Written Testimony, 4/23/84 Hazards Hearing).

(ii) Building diversion barriers to deflect lava flows has an excellent probability of success. (Campbell Exh. 6, p. 258, DOWALD Exh. 12, p. 9; KGS 8/27/84).

(iii) A well placed barrier can deflect lava flows considerably higher than the barrier itself. (Campbell Exh. 6, p. 258, Moore Testimony, Vol. IV, December 19, 1985, p. 269; KGS 8/27/84).

(iv) Division walls can be built quickly and inexpensively. (Moore Testimony, Vol. IV, December 19, 1985, p. 269; KGS 8/27/84).

(v) Geographical diversification of plants and development (Moore Testimony, Vol. VI, December 19, 1984, p. 234, 235, 238; KGS 8/27/84; DOWALD EXH. 12, p. 8; KGS 8/27/84).

(vi) Modular and portable power plants (DOWALD EXH. 12, p. 7; KGS 8/27/84).

(vii) Pipeline supports may be protected against flows with localized barriers or support structures (DOWALD EXH. 12, p. 7; KGS 8/27/84; Niimi Testimony).

(viii) If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from lava flow hazard, wells or plants can be sufficiently fortified to withstand almost any lava flow (Mullineaux and Peterson, 1974). A cost/risk analysis would have to be made. (DOWALD Exh. 12, p. 6; KGS 8/27/84).

(ix) Another well-protection alternative is to enclose the well-head in a concrete cellar allowing the lava to flow above rather than around the well-head. Recovering a well covered with a thick flow could be quite arduous and time consuming. The precise effect the lava's heat would have on the well-head mechanisms is not known. (DOWALD Exh. 12, p. 6; KGS 8/27/84).

(x) Modern metallurgy is capable of handling situations where lava is encountered on the surface or subsurface. Wellbore bridge plugs will be available to isolate any productive sub-surface formation if drilling operations must be curtailed. In addition, surface valves and blowout preventers will provide further security. The general practice is to install redundant valves or blowout preventers for reliability. The major supplier of geothermal wellheads and valves is W-K-M. They have stated that the wellheads and valves will not melt even if covered by a lava flow. Experiments by Sandia Laboratories in Kilauea Iki Lava Lake showed that the casing can be installed even in molten lava and that heat exchangers exposed to molten lava withstood the temperatures and gases. (Campbell Exh. 1, p. 4; GS No. 9/26/85-5).

(xi) Comprehensive evacuation plans will be designed to assure worker safety. Warning time prior to inundation can be as little as one hour to eruption. (Moore, 1984). Procedures will be established to protect equipment. Multiple access roads should be provided in the event one gets covered by a flow. (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xii) The development will coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory) and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xiii) If a lava flow is impending during well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing, portion of the well.

These plugs can be installed in one hour (DOWALD Exh. 12, p. 7; KGS 8/27/84).

(xiv) Trip wires, placed in the expected lava flows, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan (DOWALD Exh. 12, p. 7; KGS 8/27/84).

f. If geothermal development investors assume a major portion of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity. (DOWALD Exh. 12, p. 8; KGS 8/27/84).

g. Well heads and valves will not melt when covered by lava (Campbell Exh. 2, p. 4; KGS 8/27/84).

h. Technology for operating in magma is available from direct research experiments (Campbell Exh. 2, p. 4; KGS 8/27/84).

2. Pyroclastic Fallout

a. Is not expected to be an impact in the Kilauea Middle East Rift Zone (DOWALD EXH. 14, fig. 8; KGS 8/27/84).

b. Is not expected to be a problem more than 1 km. away from an eruptive vent or fissure (Kubacki Testimony, Vol. IV, p. 324, December 16, 1984; KGS 8/27/84).

c. Cooling towers may be affected but roofs can be designed to mitigate any impact (Kubacki Testimony, Vol. IV, p. 324, December 16, 1984; KGS 8/27/84).

d. Is not expected to be a problem because of lack of shallow ground water (DOWALD EXH. 12, p. 3; KGS 8/27/84).

3. Ground Cracks

a. Are evidence of magma intrusion into the subsurface (DOWALD EXH. 12, p. 3; KGS 8/27/84).

b. Cracks may also be caused by earthquakes (DOWALD EXH. 12, p. 3; KGS 8/27/84).

c. Tectonic ground cracking is usually localized near major fault systems such as in Hilina and Koae (DOWALD EXH. 12, p. 3; KGS 8/27/84).

d. Some cracks may not be positively identifiable because of forest cover (Jackson, Tr. Vol. VI, December 19, 1984, p. 194; KGS 8/27/84).

e. Based on crack frequency and eruption frequency, there would be greater hazard with Kahauale'a than there would be downrift. (Jackson, Tr. Vol. VI, p. 20, December 19, 1984; KGS 8/27/84).

f. Cracks are oriented primarily vertically (DOWALD EXH. 12, p. 4; KGS 8/27/84).

g. Cracks and fractures are one of the elements you look for when searching for a geothermal resource. (Jackson, Tr. Vol. VI, p. 188; KGS 8/27/84).

h. Measures to mitigate the impact of ground cracks:

(i) Steam transmission piping can be made with expansion joints to accommodate appreciable subsidence and ground movements.

(ii) Siting of facilities away from surface cracks will reduce hazards. (Jackson, Tr. Vol. VI, p. 189, December 19, 1984; KGS 8/27/84).

i. Depth of surface cracks are unknown. (Jackson, Tr. Vol. VI, p. 190, December 19, 1984; KGS 8/27/84).

j. No impact from cracks was experienced in any of the existing wells despite the fact that at least 2 of the 6 wells were sited close to the surface cracks. (Niimi 1984, Evidence of geothermal potential at Kahauale'a).

k. Impact on well drilling is unknown. A fault could intersect a wellbore without causing any damage. The fault could seal off the well or the faulting could crimp the end of the casing and not allow fluids to escape. (Jackson, Tr. Vol. VI, p. 190, December 19, 1984; KGS 8/27/84).

4. <u>Ground Subsidence</u>

a. Subsidence in rift zones are associated with magma intrusion (McDonald, <u>Volcanoes in the Sea</u>, p. 39).

b. Subsidence may be caused by fault displacement associated with tectonic activity along major fault systems such as Hilina and, therefore, not likely to affect rift zones (DOWALD EXH. 12, p. 4; KGS 8/27/84).

c. Grabens are most likely to occur in the central portion of the east rift (DOWALD EXH. 12, p. 18; KGS 8/27/84).

d. Mitigating Measures:

(i) Siting facilities away from the center of the rift zone (DOWALD EXH. 12, p. 5; KGS 8/27/84).

(ii) Installation of automatic well shut-off devices and pipeline block valves to prevent geothermal fluids from entering any damaged pipeline sections (EIS).

(iii) Geologic surveys to ensure site stability (DOWALD EXH. 12, p. 4; KGS 8/27/84).

5. Earthquakes

a. Most earthquakes in Hawaii are volcanic and result from near surface magma movements. These earthquakes are small in magnitude and usually cause little direct damage. (DOWALD Exh. 12, p. 4; KGS 8/27/84).

b. A November, 1983 earthquake registering 6.6 on the Richter scale did not cause any damage to HGP-A facilities. (Moore Testimony, Vol. VI, December 19, 1984, p. 291; KGS 8/27/84).

6. Tsunamis

a. Hazard is present only to areas below 75 feet elevations (DOWALD EXH. 12, p. 5; KGS 8/27/84).

b. Proposed Kilauea Middle East Rift Geothermal Subzone is located at elevations generally above 1,400 feet. (State Exh. 2, p. 41, KMERZ GS 9/26/85-5.)

E. Lifestyle, Culture and Community Setting

Potential social impacts resulting from a 100 MW geothermal development in the Kilauea Middle East Rift GRS would be to lifestyle, culture and community setting, aesthetics, health, and noise.

1. Population Increase

a. Puna district is the fastest growing district on the Big Island and second fastest growing district in the State in terms of population increase (Hawaii State Census Statistical Areas Committee, 1985). As such, the Puna population contains a large proportion of newcomers. The population of the district increased 128 percent during the 1970 to 1980 period and almost 41 percent during the 1980 to 1984 period. It is noted that this occurred without any major development activity in the district. The population increase has been partially attributed to diversified agricultural activities in Puna and the emerging role of Puna as a "bedroom" community for Hilo. This latter factor is expected to continue in the future. (FSEIS pp. 102-103)

b. Puna has proportionately more Caucasians and fewer Japanese than the Big Island as a whole. A large increase (311%) in the Caucasian population between 1970 to

1980 has increased the size of the Caucasian population to almost the combined population of all the other non-Caucasians excluding Hawaiians. (FSEIS p. 103)

c. Puna's Hawaiian population is proportionately smaller than the Big Island's as a whole. However, the Hawaiian population increase (195%) was also high during the 1970-1980 decade. An even larger increase in the Hawaiian population has occurred in Lower Puna. It is estimated that there are about 1,000 Hawaiians residing in Lower Puna, which is about 75% of the total Hawaiian population in the Puna district.

d. The cultural practices and lifestyles of Puna district are as varied as the ethnic composition of the population. This diversity contributes to and most likely enriches the quality of life in the district. At present, and for the foreseeable future, Protestant, Catholic, oriental and ancient Hawaiian religions and cultural ideologies are practiced in the district. (FSEIS p. 104)

e. Economically, Puna, particularly Lower Puna, has traditionally been an agricultural community. Local farmers produce the bulk of the County's papayas, anthuriums, orchids, bananas, vegetables, maile and marijuana. (FSEIS p. 105)

f. Approximately 54,000 agriculture and urban use subdivided lots are presently vacant in the Puna district.

When and how fast these 54,000 vacant lots in the district will be developed and occupied depends on various interrelated factors, such as the county's overall economy, which is in turn dependent on the state and national economy. In particular, what happens in Hilo in terms of economic activities will directly influence population in-migration to Puna and the development of those lots. (FSEIS pp. 106-107)

g. The proposed project is not expected to cause any significant changes to the rural or agricultural lifestyle presently existing in the area. The communities are expected to remain essentially rural and agriculturally oriented, as the proposed project is not expected to directly attract a major influx of population in-migration to the district. This is because the project itself is a capital intensive not a labor intensive industry. However, it is expected that there may be a gradual minor population increase due to the proposed project over the life of the project, if employees, presently living in other Big Island districts, move into the Puna district and decide to stay permanently. If it is assumed that one-half of the project employees relocate to the Puna district, the total population increase is estimated to be in the range of 158 to 255 persons. This would represent a 0.96 to 1.54 percent increase over the present Puna district population of 16,530 versus the 220 percent increase that has occurred over the past fourteen years. The 1.4% increase in the population that would directly result from the proposed project during the next 10-year period would not be expected to have any direct adverse impacts on the community in terms of public utility services and public facilities. (FSEIS p. 108; Applicant's Exh. 5, p. 4)

h. Economically, the proposed project will provide employment opportunities in three basic construction areas (road construction, well drilling and pipeline/power plant construction) and in pipeline and power plant operation and maintenance. (Table 26 of the FSEIS p. 110, identifies the estimated number of employees required over the life of the project.) These estimated number of employees are: road construction: 15-25 workers, well drilling: 15-20 laborers, pipeline/power plant construction: 60-100, construction workers, pipeline/power plant operation: 670 engineers and operators. (FSEIS p. 110; Applicant's Exh. 5, p. 3)

i. Based on the project's development schedule, it is probable that the initial labor required for road construction and well drilling activities will be needed as soon as the project begins, i.e., mid-1986. Initial labor forces required are estimated to be around 50 workers, perhaps 10 to 15 for well drilling activities and the remainder for road construction. The pipeline/power plant labor will be required beginning in mid-1987. All labor forces will be employed either continuously or intermittently during the 10-year development/construction period. Power plant operations and maintenance personnel will be required as power plants come "on-line" in 1989, 1990, and 1995. (FSEIS pp. 110-111)

j. It is expected that the majority of the employment positions will be filled by present Big Island residents because there are sufficient levels of work skills and labor forces available. The employment of Puna district and/or island of Hawaii residents to fill the construction and plant operation positions is expected to have a positive impact on the economy of the island in general and specifically the Puna district. It is estimated that the average annual income per employee will be approximately $22,500. Assuming a work force of 100 employees during the first 10 years of construction/operation, total wages would be $2,250,000 per year. If an expenditure multiplier of 2 is assumed and it is assumed that only one-half of the income is expended in Puna district, the net annual increased expenditure in the district would be $2,250,000 and the increased expenditure for the island or the state would be an additional $2,250,000 per year. (FSEIS p. 111; Applicant's Exh. 5, p. 4).

k. At present, hunting is allowed in the Puna Forest Reserve and "gathering" is allowed outside of the Wao Kele O Puna Natural Area Reserve upon issuance of a permit for gathering for personal use only. The transfer of hunting rights from the project area to Kahauale'a would lessen the impact of locating the proposed project on the state lands. (FSEIS p. 112)

l. During the exploration stage of the project, it is estimated that there will be approximately 16 to 20 trips per average 24-hour day. During the development stage, it is estimated that an additional 20 trips per average 24-hour day will occur. During the operational stage, it is estimated that a total of no more than about 15 trips per average 24-hour day will occur. This traffic will consist of construction workers, materials and supplies deliveries including any chemicals required by the abatement systems used, operations and maintenance personnel and visitors. (FSEIS p. 114)

m. If required, workers could be bussed or car-pooled into/out of the project area. The transportation of all heavy, slow moving equipment will be performed during off-peak traffic periods during daylight hours and coordinated with the County Police Department. Also, all traffic into and out of the project area will be via a controlled access security gate.

n. The planned traffic/transportation controls will minimize traffic increases on the roadways in the vicinity of the project area. As such, the limited increased traffic is not expected to impact existing lifestyles, cultural practices or commercial or recreational practices and activities in the areas surrounding the project area. (FSEIS p. 115)

2. Hawaiian Religion and Culture

One of the issues raised recently about geothermal development involves the impact of such activity under the traditional culture of the Hawaiian community. These concerns are focused on the potential conflict over the use of the land in culturally compatible ways and the potential interference with the application of certain Hawaiian cultural practices. These practices are the right to gather food, medicinal plants and maile, and to hunt in the proposed development area as well as the effect of the development itself on Pele Practioners. (Murabayashi, Tr. Vol. VII, February 20, 1986, pp. 8-9.)

a. Traditional Hawaiian land system.

(1) In the traditional Hawaiian land system, where no one truly owned the land, the person charged with the responsibility of management of a moku, ahupua'a or any other parcel of land, had the duty and responsibility of deciding how such land was to be used. In this instance,

whoever owns the land involved in this case should have the responsibility of deciding how he should develop, improve, or otherwise make that land productive or useful. (Applicant's Exh. 19, p. 3; Piianaia, Tr. Vol. XI, February 23, 1986, p. 45-46, 48, 57).

(2) In spiritual matters in Hawaiian culture, ancestral authority is not a higher authority than that of the landowner. (Piianaia, Tr. Vol. XI, February 23, 1986, p. 58.)

b. Traditional Views.

(1) The Pre-Pele Era. In the traditional chronology of volcanic events in the Hawaiian Islands, the responsibility for volcanism is the responsibility of the major god Ku (there were four major gods: Ku, Kane, Lono, and Kanaloa). The deity to which this responsibility was delegated, as recited in the early traditions, was a god named 'Aila'au (in this particular application, the name means "one who consumes forests"), a male. Why this was so may logically be attributed to the idea that the earliest settlement of these Hawaiian islands was a fantastic conquest of man over the elements which, in the minds of the people of the time, was indeed a major job of the male gender. There is very little known today of this early god of volcanism despite the fact that studies of the various landscapes in the Hawaiian Islands indicate strongly that

volcanism was just as active in the earlier settlement period as it has been in more recent times. Inasmuch as the name of this god is not found or repeated elsewhere within the Polynesian area, it is reasonable to surmise that the god 'Aila'au is indigenous to the Hawaiian tradition. (Applicant's Exh. 19, p. 1).

(2) Pele: A migrant to the Hawaiian Islands sometime after the earliest settlement was stabilized, Pele is the current goddess of volcanism, a responsibility she has ably shouldered for perhaps a thousand years or so. Her domicility can be traced back to several other islands of Polynesia before coming to the Hawaiian Islands, among these being Tahiti, Samoa, and Aitutaki. Among the current native inhabitants of these areas, traditions relative to the sojourn are hazy. What this tells us, however, is that Pele is a goddess not truly indigenous to Hawaii. Despite this, she has done a fantastic job in capturing the attention, the awe, the imagination, the respect of almost all of us in Hawaii; even the sincere worship of some of us. (Applicant's Exh. 19, p. 1; Piianaia, Tr. Vol. XI, February 23, 1986, p. 43).

(3) Halemau'uma'u and Moku'aweoweo. These are the names of the volcanic craters at Kilauea and Mauna Loa volcanoes, respectively. Most of the writings in the past 50 years or so indicate that Halema'uma'u is the home of the

goddess _Pele_. However, as a youngster, Mr. Abraham Piianaia, the head of the Hawaiian Studies Program at the University of Hawaii, was repeatedly told by his grandparents that the _Moku'aweoweo_ is the actual home of _Pele_, but that she often did some of her volcanic chores at _Halema'uma'u_. An examination of these place names sheds some light on the subject. Translated, _halema'uma'u_ means "home of the _ma'uma'u_ fern"; _Moku'aweoweo_ means "a fiery red island" which refers to what the firepit looks like, particularly during an eruptive cycle. Mr. Piianaia was also told by his grandfather that in his youth, those Hawaiians who were truly devotees of _Pele_ paid homage to Pele at _Moku'aweoweo_. With the building of roads which made _Halemau'uma'u_ more conveniently accessible, the establishment of the Volcano House as a hostelry at the rim of _Halema'uma'u_, and the increased visitor interest in the area, people began to refer to the crater at _Kilauea_ as the home of _Pele_. But still another spin-off results from this change--the growth of a cult which considers _Pele_ as its major godhead materializes. Hula groups make pilgrimages to honor the fire goddess in song and dance. In Beckwith's _Hawaiian Mythology_, the compilation of which took place nearly 60 years ago and included research information provided by highly respected native Hawaiian scholars such as Beckley, Wise, Kupihea who were already over 50 years of age, it is stated that Pele approaches the Hawaiian Islands "from the northwest, tries island after island without success, and finally settles on Hawaii at the crater Moku-a-weoweo." (Applicant's Exh. 19, p. 1-2).

(4) Pele's impetuousness. Most Hawaiians have a feeling that Pele is not a wanton goddess who would deliberately go out of her way to hurt anyone. This could be absolutely true even today, EXCEPT for those who have experienced the result of Pele's occasional destructive outpourings. In 1926, almost the entire village of Ho'opuloa was made up of Hawaiians who had great faith that their volcano goddess would not harm them. Because of this faith, none of them did anything to remove their belongings--just in case. When the molten mass of red hot lava about 30 feet high and at least 700 feet wide showed no signs of changing its course, some residents removed ther household goods and livestock to safety, but hardly anything else was saved. The flow of lava consumed the entire village and continued on its way to the nearby sea. Last attempts at appeasement through the offering of pigs, chickens and other objects to Pele failed; the long standing belief that no Hawaiian village would ever be consumed by volcanic action because Pele protected her own people was no longer so. This specific lava flow of 1926 is well documented. (Applicant's Exh. 19, p. 2).

c. Modern Views.

(1) In the survey done by Puna Hui Ohana, Assessment of Geothermal Development Impact on Aboriginal Hawaiians found that "the question asking about overall: impact of geothermal development in Puna produced responses in the "neither good nor bad" middle ground. There seems to be a balancing of the potential economic benefits of geothermal development with the environmental and social costs of development. (DOWALD Exh. 8, p. 9-10).

(2) Pele Practitioners. The Pele practitioners, R.P. Dedman and E. Aluli, have stated that the commercial development of geothermal energy will be an impermissble interference with their native Hawaiian right to practice their religious reverence for the Goddess Pele. (Dedman and Alului, written testimony, Kilauea Middle Rift Geothermal Subzone, November, 1985).

(3) These Pele practitioners believe that the Goddess Pele is embodied in the geothermal resource and that the utilization of that resource is a desecration of Pele. (Dedman, Tr. Vol. V, p. 143, lines 23 and 24).

(4) To many native Hawaiians, Pele is regarded as an akua or an aumakua and personal offering are made to Pele as part of religious practice. (DOWALD, Exh. 2, 3rd Paragraph, p. 13).

(5) Some native Hawaiians also identify themselves as the bloodline of Pele and believe that geothermal development may forever extinguish or destroy essential parts of Hawaiian heritage, culture and religion. (DOWALD, Exh. 2, 3rd paragraph, p. 13).

(6) Pualani Kanahele, a Pele practitioner, stated that the people of Hawaiian ancestry from the island of Maui, from the island of Oahu, from the island of Molokai and wherever else they live in this world, has no connection to this diety [Pele] herself. There is very few, a handful of people, that has this connection to Pele. (Kanahele, Tr. Vol. VIII, February 21, 1986, p. 110).

(7) The belief that the development of geothermal steam for the generation of electricity is a desecration of Pele is not universally shared by all native Hawaiians. Historical accounts of native Hawaiian activity show that they used geothermal steam for cooking food for non-religious purposes such as feeding animals. (Account of Rev. Ellis; Handy and Handy, DOWALD, Exh. 2, 5th paragraph, p. 13).

(8) Other native Hawaiians currently believe that the development of geothermal energy is not counterproductive to native Hawaiian culture and heritage. One of these native Hawaiians has stated that, " . . . as a Hawaiian who shares the love of this land with others,

cognizant of my heritage and traditions, I feel my ancestors would be proud to know that we are trying to use our natural resources in the best way possible. The Hawaiian of times past, with his astute knowledge of all things and through the proper observances of established laws, used all of the natural resources available in their limited way to do the most good for the most people." (Testimony of G. Jenkins, Public Hearing on Middle Rift Geothermal Subzone, September 26, 1985).

(9) Other people speaking on behalf of Hawaiian civic groups have spoken in support of geothermal development. The president of the Hawaiian Civic Club in Ka'u stated in support of the designation of a geothermal resource subzone that, ". . . we are not living in the past now. There's a lot of things we need to preserve, and yet there's a lot of things that sometimes we have to give up for the betterment of our own Hawaiian children and families. Now, we speaking on behalf of myself, talking about geothermal, I cannot say that I know too much about geothermal. But I think I know enough that I would sit here and support the geothermal resource subzone . . . ." (Testimony of A. Carriaga, Public Hearing of the Kilauea Southwest Rift Zone Geothermal Resource Subzone, September 26, 1985).

(10) Campbell Estate, whose beneficiaries are also Hawaiian, contemplated the concerns of Pele Practitioners and decided to address this issue by visiting with Hawaiian community leaders, scholars, and theologians to evaluate this concern. A team consisting of three Hawaiians, Mr. Oswald K. Stender, Chief Executive Officer; Mr. Sam Keala, Manager, Engineering and Construction; and Herman Clark, Jr., looked into the matter on behalf of the Estate. They met with twenty-three groups and thirty individuals such as the Kalapana Community Organization; Alu Like Board/island of Hawaii; and University of Hawaii-Hilo, Hawaiian Studies students. (Applicant's Exh. 6, p. 2; Clark Tr. Vol. IV, p. 89, FSEIS pp. 112-113.)

(11) All of the people who were contacted shared a respect and reverence for Pele. Similarly, they also expressed a sensitivity to the rights of other Hawaiians who are Pele practitioners. However, the majority view expressed by the people contacted was that the importance of the development of geothermal energy to the economy and future of the State of Hawaii and to all of its people, should not be ignored and left unexplored. It was felt that the development of geothermal energy in Hawaii could be interpreted in a positive light for the Hawaiian community as well as the State. (Applicant's Exh. 6, p. 2-3; Clark, Tr. Vol. IV, p. 91, 96).

d. <u>Mitigating measures</u>.

(1) The potential impact on the practice of gathering food, medicinal plants and maile can be lessened to the extent that any of the gathering rights will be transferred to Kahauale'a through the land use exchange. It may also be mitigated by allowing freedom of gathering for personal use on a permanent basis within safe areas of the proposed geothermal resource subzone (Murabayashi, Tr. Vol. VI, February 20, 1986, p. 12).

(2) As to the perceived conflict between the beliefs of the Pele Practioners and geothermal development, possible mitigating measures are continuously sought, and consideration of the potential conflicts of the Pele Practioners together with kupunas, the land owners, and all geothermal developers. This can be done through a continued and honest dialogue among the involved parties and various other groups and individuals, particularly Hawaiians and part-Hawaiians (Murabayashi, Tr. Vol. VI, February 20, 1986, pp. 12-13).

<u>3. Aesthetic Concerns</u>

a. The proposed geothermal resource subzone is located in an area 3-6 miles from potential view corridors along the eastern edge of the Hawaii Volcanoes National Park, the Hawaiian Belt Road, and upslope of the project area. (Applicant's Exh. 5, p. 5).

b. The tallest structure within the proposed project area will be a 150' (15-story height) drilling rig. It is anticipated that throughout the project development only 1 drilling rig will be utilized. The second highest structure may be a 65 foot power plant. (Applicant's Exh. 5, p. 5).

c. Some people may perceive that these structures together with varying pipelines and access roads may create conflicting views within the mostly forested area. However, in view of the remoteness of the area, view corridors especially from the Hawaii Volcanoes National Park, and from the residences surrounding the area are extremely limited and therefore, the permanent structures on the development should not pose a serious problem to the visual aesthetics of the area. (Applicant's Exh. 5, p. 5).

4. Conclusion

Overall indications are that the elements of major social concerns and impacts could be minimized and preservation of quality environment could be achieved by proper siting, landscaping and design of plant facilities, and careful controls and monitoring of all operations. The necessity and desirability of furthering the on-going processes of accessing community input from all sectors should be emphasized particularly with the Hawaiian community. (DOWALD Exh. 8, p. viii, Murabayashi, Tr. Vol. VI, February 20, 1986, p. 13.)

F. Health

1. Health Concerns.

a. A major concern of the public regarding geothermal development has been the effects of any geothermal emissions, particularly hydrogen sulfide (H_2S), as it affects their health. (Applicant's Exh. 5, p. 6).

b. A survey conducted by SMS Research, Inc., for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, The Puna Community Survey, completed in April, 1982, interviewed 778 residents in the Puna area and among the questions asked was the following:

> Question No. 18 [3]: "Have you or members of your household been affected by those wells in any way? [Geothermal wells in Puna]."
>
> Only 18% of the respondents answered "yes" and 81% of the respondents answered "no", with 1% answering "Don't know."
>
> (DOWALD Exhibit 8, p. 2, KMERZ GS 9/26/85-5.)

c. The ambient air H_2S standard currently under study by the State of Hawaii Department of Health recommends that man made sources of H_2S not add more than 0.025 ppm of H_2S to the existing ambient levels and imposes an absolute ceiling concentration of 0.100 ppm H_2S when man made and natural H_2S sources are combined. (Applicant's Exh. 5, p. 6).

d. Review of this proposed standard by environmental epidimiologist found that the lowest level of H_2S capable of producing objective signs of tissue damage in man as 10.0 ppm and that a standard based on a 100 fold safety factor below this level should be adequate to protect the general public from adverse health effects of H_2S. (Applicant's Exh. 5, p. 6).

e. A review of California's ambient air H_2S standard of 0.030 ppm similarly found that this level was adequate to protect human health. Hence, compliance by the developer with the currently proposed Department of Health ambient air standard of a 0.025 ppm increment and 0.100 ppm absolute concentration should, in light of the latest research, prevent adverse health impacts from the proposed 100 MW development on the surrounding population. (Applicant's Exh. 5, p. 6-7).

f. Of the 18% of households which indicated that they were affected in any way by geothermal wells in Puna, only 14% indicated they were affected by health problems while 71% perceived smell as the negative effect of geothermal wells. (DOWALD Exh. 8, p. 2)

g. In the "Puna Speaks" case, where the HGP-A plant was challenged by Puna residents, the U.S. District

Court ruled that the plaintiffs did not prove their case in the suit as no causation was established between the well emissions and the maladies alleged by the plaintiffs which they claimed were caused by the HGP-A plant. (DOWALD Exh. 8, p. 3).

h. A standard survey form developed by the National Center for Health Statistics was used to survey and compare the health status in the community of Leilani Estates to the community of Hawaiian Beaches. The survey was done by a committee appointed by the Department of Health headed by Dr. Bruce S. Anderson (Testimony of Bruce S. Anderson, Vol. VI, February 20, 196, p. 49-50).

i. There were two primary purposes for taking the survey: one was to establish baseline health information in the event geothermal resources were further developed in the area, and the other was to address some immediate concerns of the residents, that their health was being compromised by the existing emissions from the HGP-A well. (Testimony of Bruce S. Anderson, Vol. VI, February 20, 1986, p. 49).

j. The study conducted by the Department of Health concluded that there was no statistically significant difference in the health status of the two communties. The study included the rate of respiratory conditions which include bronchitis, emphysema, asthma, hay fever, sinusitis, which are associated with exposure to air pollutants.

(Testimony of Bruce S. Anderson, Vol. VI, February 20, 1986, p. 96).

k. Two residential communities were selected for study: (1) "Leilani Estates," a community that is directly and downwind of existing geothermal wells (on prevailing trade wind days); and (2) a portion of "Hawaiian Beaches Estates" as a control. Leilani Estates was selected because of its close proximity to the HGP-A well and history of complaints associated with geothermal development activities. Hawaiian Beaches Estates was selected as a control for comparison because of its location (normally, during prevailing trade wind days, upwind from existing geothermal wells) and, presumably, similar demographic characteristics. (Sierra Club's Exh. 10, p. 6.)

l. Dr. Anderson testified that it could be said fairly competently that there was no impact that could be associated with H_2S for any particular environmental problems in the Leilani Estate areas when compared to the Hawaiian Beaches. (Testimony of Bruce S. Anderson, Vol. VI, February 20, 1986, p. 102).

m. If a person was exposed to an environmental hazard which may have insidious affects, one would certainly expect exasperation of predisposing illness and possibly some of this exposure may result in some common respiratory illness, but there was no finding of this in Leilani

Estates. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 97).

n. The study that was done was satisfactory in the sense that at that point in time there was no difference in the health status of those two communities surveyed. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 89).

o. There is no evidence in the literature that shows that H_2S is carcinogenic or mutagenic or teratogenic or that it effects the reproductive system. Nor is there any evidence in the literature to suspect an increase in chronic respiratory disease, H_2S doesn't necessarily cause asthma or emphysema or bronchitis, although it's possible that people with those conditions may be more susceptible. However, even that relationship is not substantiated in the literature. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, pp. 59-60).

p. Evidence suggests that an individual who survives a single high level exposure to H_2S usually recovers rapidly and completely. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 61).

q. The lowest level at which health effects have been observed, that is decreased reflexes and eye irritation is about 10 parts per million or 10,000 parts per billion. If a safety factor of 100 is put in, that level is down to

100 parts per billion. The safety factor is added to protect high risk individuals. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 69).

r. A healthy individual would not have any physiological problems until levels exceeded 10 parts per million or 10,000 parts per billion. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 70).

s. A safety factor of 100 ppb is appropriate. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 69).

t. Detecting odor doesn't necessarily imply an odor nuisance. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 70).

u. Dr. Anderson felt comfortable in saying that no matter how many samples or how many surveys are taken, it may never be known if H_2S is a factor affecting diseases. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 92).

v. In any study it would be difficult to show a direct cause and effect relationship. Any relationship would be secondary at best and would be subject to the judgment of whoever was reviewing the report. (Testimony of Bruce Anderson, Vol. VI, February 20, 1986, p. 52).

2. *Noise Aspects*

a. Noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size. (DOWALD Exh. 8, p. 4).

b. In May of 1981, the County of Hawaii Planning Department issued a set of Geothermal Noise Level Guidelines to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. Because these guidelines answer directly to the noise concerns, they are presented in the following excerpts:

> In granting Special Permits for the exploration and development of geothermal resources in the Puna District, the Planning Department and Commission found that there were potential adverse impacts to the surrounding area which may result from the geothermal operations. Consequently, stringent controls and conditions were attached to the respective permits. The Planning Commission assigned the Planning Director the primary responsibility for the monitoring and enforcing of these conditions.
>
> In light of these responsibilities and the numerous noise related complaints received from residents of the Puna District concerning certain geothermal drilling operations, the Planning Department has developed the following guidelines to determine acceptable noise levels for both geothermal exploration and production.
>
> These noise levels are intended to provide the Planning Director with the necessary guidance to review and assess geothermal operations on a case

specific basis to determine whether a noise nuisance exists or not. Based on this review, should the Planning Director find that the acceptable noise levels are being exceeded and that the residents are being significantly adversely impacted by that noise, he can: (1) invoke more stringent noise mitigative procedures and/or mitigative devices; or (2) ease further geothermal activity in accordance with the appropriate provisions of the Special Permits.

Guidelines

In conjunction with the various acceptable noise standards and the factors specifically affecting the Puna environment, the Planning Department has developed the following noise level guidelines for geothermal activities:

1. That the acceptable geothermal noise guidelines should be at a level which reasonably assures that the Environmental Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met.

2. That the sound level measurements should take place at the affected residential receptors.

3. That, in conjunction and appreciation of the other guidelines, the acceptable noise levels for geothermal development are as follows:

    a. That a general noise level of 55 dBA during daytime and 45dBA at night not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours of 7:00 p.m. and 7:00 a.m.;

    b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period.

    c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation; and

d. That sound level measurements be conducted using standard procedures with sounnd level meters using "A" weighting and "slow" meter response unless otherwise stated.

The guidelines for allowable geothermal noise levels are intended to provide an interim basis for assessing geothermal activities. As more information is obtained and a better understanding of both the noise levels and their impacts on the environment and the climatic conditions affecting the Puna area, these guidelines should be amended.

c. The noise source associated with initial construction operations, well drilling and testing, power plant operations and reservoir maintenance will be the same in the Kilauea Middle East Rift as those described for Kahauale'a. The major diffence for the proposed project is that the noise sources would be located at greater distances from the National Park and to relatively denser populated areas, e.g., the town of Volcano. (Applicant's Exh. 12, p. 1-2).

d. <u>Construction operations</u>. The building of roads, well sites, and power plants will involve standard construction equipment--bulldozers, graders, and trucks, etc. operating in the same manner, and over a limited time period, as any other typical project: e.g., county road building, and clearing of agricultural land. No unusual noise events of long duration are involved. (Applicant's Exh. 12, p. 2).

e. Geothermal well drilling and testing. Well drilling will be accomplished by the 24-hour use of a modern diesel-powered drilling rig accompanied by such ancillary diesel-powered equipment as electric generators, air compressors, mud pumps and portable cranes. The majority of the well drilling is anticipated to be air drilling where air is blown into the hole to cool the bit and bring up cuttings and debris. Large diesel-powered air compressors will be used. At times, the drilling instead utilize drilling mud which is forced into the hole by large diesel-powered mud pumps used in the drilling operation which will cause sound levels of 85 to 95 dBA at 100 feet.

Based on noise levels obtained from well drilling equipment which have had considerable noise control measures implemented in the Pahoa area of the Big Island and in the Geysers, California, the effective noise source level of 82 dBA at 100 feet is anticipated from the drilling site taking into consideration all equipment operating simultaneously. Achieving this noise source level not only dictates "hospital-type" engine exhaust silencers, but also various degrees of full and partial acoustical enclosures around selected diesel-powered equipment. It also dictates that when drilling with air, a large, high quality separator-silencer with adequate water injection be used to reduce noise from the steam and air discharge. This level of noise reduction has been achieved for drilling rigs with state-of-the-art equipment as exemplified by the Lake County, California proposed noise standards for geothermal drilling rigs of 82 dBA at 100 feet. If found necessary, further noise abatement measures on the drill rig itself would be implemented. (Applicant's Exh. 12, p. 2-3).

f. It is the intention of the developer not to free vent wells into the atmosphere unless necessary for cleaning, testing, or stabilization since noise levels of 120 dBA at 100 feet can readily occur. Large rock mufflers, here and at the Geysers, have reduced venting noise to 80 dBA at 100 feet. However, if a situation should arise where free venting was found to be necessary, it will only be done for a limited number of hours during the daytime, and only if favorable weather conditions exist. (Applicant's Exh. 12, p. 4).

g. Geothermal power plants. The primary noise sources associated with geothermal power plants are steam lines including steam bleeding, the turbine building, cooling towers, and transformers. Steam line noises including throttling can be reduced to insignificant levels by special acoustic lagging of the pipe and/or selected fittings. Bleeding of steam has been eliminated in modern geothermal plants by the use of collector lines. Buildings and barriers can be designed to optimize the orientation and degree of closure to contain noises from the turbine, generators, and pumps. Cooling towers have not proven to be dominant noise sources in geothermal plants, typically 68 dBA at 100 feet. Taking all major noise sources into account, the continuous noise level of 75 to 75 dBA at 100 feet is considered readily achievable for power plants in the geothermal resource subzone. (Applicant's Exh. 12, p. 5).

h. Well drilling. In order for well drilling operations to cause less than 45 dBA during sound propagation Condition No. 2 (wind conditions of greater than 5 and less than 10 mph), a downwind receptor must be about 4,500 feet distant. If a major topographical feature, such as Heiheiahulu, was located between the drill rig and the downwind receptor, a receptor could be located much closer without exceeding the 45 dBA. If the receptor is located upwind of the drill rig, distances of only about 1,000 feet would be adequate to reduce noise levels to 45 dBA. (Applicant's Exh. 12, p. 5-6).

i. When the winds are very light, such as less than 2 mph (about 14% of the nights and 5% of the days), there is the possibility of sound focusing. This phenomena causes higher than normal noise levels to occur in small areas. This fluctuating condition would most likely occur with the proper combination of light winds and a thermal inversion or in the rare instances of no wind and a very strong inversion. When there is no wind, the sound focusing is not directive and causes higher noise levels in small annular rings. When there is focusing of sound, temporary sound level peaks of 45 dBA may exist between 1-1/2 to 2 miles from the drill rig, but they would generally be fluctuating such that the temporal conditions in the County Guidelines should not be exceeded. (Applicant's Exh. 12, p. 6).

j. Knowledge of the noise source levels and the sound propagation conditions allow control of the noise levels from geothermal well drilling such that they will not exceed the acceptable levels in the County Guidelines at the nearby residences. Several wells have been drilled since 1982 near the HGP-A site and it is understood that no noise complaints have been received from the residents living less than one mile distant even though they were often downwind of the rig and worst-case sound propagations must have occurred. This is considered evidence that adequate noise mitigation measures can be applied to the drill rig and ancillary equipment to control any adverse noise impacts. (Applicant's Exh. 12, p. 7).

k. Power plants. Equipment associated with power plants is basically quieter than the diesel-powered units required for drilling. Furthermore, the permanency of the power plant allows the implementation of noise mitigation features beyond that which is practical for drill rigs. Power plant noise should be inaudible at about one mile under the worst-case propagation conditions.

l. Venting through rock mufflers. The overall noise levels from venting through rockmufflers not only are lower than those from drill rigs, but most of the sound energy is at mid-and-high frequencies from the drill rig. Forty-five dBA noise level contours for an 80 dBA (at 100 feet) rock muffler would be somewhat larger than those shown for the power plant, but considerably smaller than that shown for the 82 dBA drilling.

m. Free venting. Noise levels from all geothermal operations would meet County Guidelines except for those rare cases when wells must be free vented into the atmosphere. Free venting of wells would be done only during the daytime, preferably during favorable sound propagation conditions (e.g. winds greater than 10 mph).

G. Environmental Impacts

1. Meteorology

1.1 Data Collected

a. From August 1982 through December 1984, a wind station at Fern Forest collected continuous wind data for the project. The station's wind data are the basic wind data for establishing the wind climatology of the project in the original Kahauale'a project area and in the present project area. (Applicant's Exh. 10, p. 3.)

b. Other wind stations and networks were started in 1983 and 1984 by NEA, Inc. For the Hawaii State Department of Planning and Economic Development, through which continuous data were collected at Upper Leilani and National Park Visitors Center for 1983. For the Kahauale'a project, wind data stations and network with collection at Fern Forest, Mauna Loa Estates, Volcano Golf Course, Thurston Lava Tube Site, Chain of Craters Road, Royal Gardens Subdivision Site, Kaimu-Makena Homestead Site, and Wakahekahe were operated in 1984 and early 1985. (Applicant's Exh. 10, p. 3.)

c. NEA, Inc. also collected wind data from other established wind stations: Woods Residence from Thermal Power Company; Volcano National Park Headquarters, Hilina Pali Road, Kalapana, Mauna Loa Strip Road, Naulu, Napau from the National Park Service; and Volcano Village from R. McBride. (Applicant's Exh. 10, p. 3.)

d. NEA, Inc. summarized all of the wind data from the above collection efforts to establish a readily available weather data base for use related to geothermal development in the Kilauea east rift zone. (Applicant's Exh. 10, p. 3.)

e. The locations of these wind stations are shown in Applicant's Exhibit 10(d). The main project wind station located at Fern Forest collected wind data from two heights, 25 feet and 50 feet. Wind data from all wind stations, especially those with continuous wind measurements, were used in this second wind analysis to update the wind climatology for the area. Wind data from Waikahekahe, Kaimu-Makena Homestead Site and Napau were most useful in correlating with general weather patterns over the area and with the Fern Forest Station. (Applicant's Exhibit 10, p. 4-5).

<u>1.2 Characteristics of Wind in Project Area</u>

a. From a review and analysis of all collected data, it was concluded that the basic wind data collected at the Fern Forest meteorological station through continuous monitoring over a 2-year period is representative of the winds in the Kahauale'a and Puna Forest Reserve areas. (Applicant's Exh. 10, p. 3.)

b. The northeast trade winds which prevail during the day and the northwesterly drainage winds which prevail during the night. (See Exhibits 10(e) and 10(f) for the updated daytime trade wind flow and nighttime drainage wind flow, respectively). There is no significant difference between the originally proposed wind flow patterns for the project area and the updated wind flow patterns based on the collected wind data. (Applicant's Exhibit 10, p. 5).

c. Trade winds during the day and drainage winds during the night dominate the wind frequency. During the day, trade winds (from the north-northeast through east) prevail 71% of the time compared to the originally proposed 77% of the time. During the night, northerly drainage winds (from the northwest through north) prevail 44% of the time compared to the originallly proposed 65% of the time. The reason for the smaller percentage of the nighttime drainage winds from the north sector was that the drainage winds also flowed from the west sector (west-northwest throught west-southwest) 28% of the time. Initially, westerly winds at the project area were not expected because broad scale westerly winds are rare in the Hawaiian Islands and these winds would be blocked from entering the project area by massive Mauna Loa. However, at the project area, the nighttime drainage winds which are normally from the north through northwest direction, were also measured to flow from the west-northwest, west and west-southwest. Adding the percentages of the winds from the north through west-southwest for the drainage winds resulted in a total of 72% for the current drainage winds which compares well with the 65% of drainage winds initially expected. (Applicant's Exhibit 10, p. 5-6).

1.3 Wind Speed

a. There is a great difference in wind speeds between 25 feet and 50 feet heights in the project area. At Fern Forest, where wind measurements were taken at 25 feet and 50 feet heights, the average wind speed during the day was 7.5 mph at 50 feet height while the average wind speed at 25 feet height was only 3.3 mph. At night, the difference between the two heights was still great: 5.2 mph at 50 feet height and 2.4 mph at 25 feet. This difference in wind speed between 25 feet and 50 feet at the same location illustrates the increase in wind speed from the ground to at least a few thousand feet upward.

There is a significant difference in wind speed between the day and night. At Fern Forest, the average daytime wind speeds were 7.5 mph and 3.3 mph at 50 feet and 25 feet heights, respectively. The average nighttime wind speeds were 5.2 mph and 2.4 mph at 50 feet and 25 feet heights, respectively. This difference in wind speeds between day and night illustrates the comparison of the higher daytime trade wind speeds and the lower nighttime drainage wind speed in the project area.

The overall wind speeds are mainly light to moderate. At Fern Forest, the average wind speed as only 6.4 mph at 50 feet height and only 2.8 mph at 25 feet height. At 50 feet height, only 1% of the wind speeds were greater than 15 mph (between 15 and 19 mph), with the rest of the wind speeds below 15 mph. During the day, 75% of the wind speeds were less than 10 mph and during the night, 95% of the wind speeds were less than 10 mph. (Applicant's Exhibit 10, p. 67).

<u>1.4 Daytime Winds</u> (8:00 a.m. - 8:00 p.m.)

a. Tradewinds, winds from the north northeast through east, which are the dominant winds, occurred 71.38% of the time.

b. Southerlies, from the east-southeast through southwest, occured 12.6% of the time.

c. Northerlies, from the northwest through north, occurred 13% of the time.

d. Westerlies from the west-southwest through west-northwest, occurred 3.1% of the time. (Applicant's Exhibit 10, p. 7-8).

1.5 Nighttime Winds (8:00 p.m. - 8:00 a.m.)

a. Northerlies, the majority of the nighttime drainage winds, occurred 43.6% of the time.

b. Westerlies, which are the result of drainage winds and some southerly winds, occurred 38% of the time.

c. Winds from the north-northeast through east (trade wind direction) occurred 20.7% of the time.

d. Southerlies occurred 7.5% of the time. (Applicant's Exh. 10, p. 8.)

1.6 Temperature Inversions

The occurrence of nighttime ground termperature inversion has not yet been measured in the project area. Although the conditions are not entirely the same at Hilo Airport and the project area, and the ground temperature inversion at the airport area cannot be totally transposed to the project area, it would be relevant to study and apply the 2 a.m. upper air soundings at Hilo Airport which indicate a ground temperature inversion on most soundings. The average monthly strength of the temperature inversion between the surface and about 450 feet is about $2^{O}F$. This temperaure inversion is due to the nighttime cool drainage air flow from the mountains and the radiational cooling of the surface at night.

At the project area, the cool drainage air flow plus the radiational cooling of the land at night are both expected to contribute to the formation of the ground temperature inversion on most nights with light winds. The temperature inversion may not exist during nights with strong winds or heavy rain. Based on the drainage wind height of 180 feet at Mauna Loa Observatory (Mendonca and Iwaoka), maximum drainage wind heights of 160 to 650 feet (Ekern and Garrett), and the average height of the top of the ground temperature inversion at about 450 feet at Hilo Airport, the height of the top of the temperature inversion at the project area is estimated to range from 200 to 500 feet. Its strength (temperature difference between the ground and top of inversion) is estimated to range from $0^{o}F$ to $4^{o}F$ with an average strength of $2^{o}F$ occurring on most nights. The wind speed of the drainage wind is estimated to be 1 to 4 mph.

To measure the strength and duration of the ground temperature inversion, a record of temperatures taken during the period of the inversion at about 5 feet height to at least 200 feet height will have to be recorded by a pair of sensitive sensors. (Applicant's Exhibit 10, p. 9-10).

<u>1.7 Air Dispersion Modeling</u>

a. In order to assess the potential impact of the proposed geothermal development, Applicant's air dispersion modelling expert, Dr. Daniels, investigated a number of meteorological situations which could generate high concentrations. These situations can be divided into two catergories:

1. Situations with a mean wind direction prevailing through the period.

2. Situations with stagnating air for several hours i.e. period without a distinct mean wind direction.

The first category comprises simple advection situations which were modelled using an EPA (NOAA 1983) recommended model.

For the second category a non-EPA model was used as no appropriate model for this situation was readily available from the EPA. This model is only a puff model variant of the continuous source model used for the first category. (Applicant's Exhibit 11, p. 2-3).

b. Calculations were made for a 55 MW plant emitting 15 gr/MWhour or 2.3 gr/sec of hydrogen sulfide during operations and 3.1 gr/sec during stacking. Other plant characteristics used are taken from a Dames and Moore report to the EPA (1984) except for the cooling tower exit velocity temperature where a more conservative value recommended by Dr. Thomas (1985) was used.

Only hydrogen sulfide emissions from power plant operation and stacking are included in the assessment as these are most likely operations to potentially violate proposed State of Hawaii ambient air quality standards. (Applicant's Exhibit 11, p. 3).

c. The commonly used and EPA recommended Gaussian diffusion model for a continuous source was used to estimate concentrations for situations with a distinct mean wind direction. (Applicant's Exhibit 11, p. 4).

d. No surface reflection was assumed in the study done by Dr. Anders P. Daniels because surface reflection was developed for urban areas. (Daniels Testimony, Vol. VIII, February 21, 1986, p. 32).

e. The wind speed affects estimated concentrations in two ways:

* low winds produce poor initial mixing but allow emissions to be lifted to several times the physical stack height; and
* high winds provide large initial mixing but prevent emissions rising far prior to losing vertical momentum

f. The plume rise was calculated from Brigg's expressions as given in the NOAA (1983) report. From the ambient temperature a night time value of 73°F was used based on temperature records from nearby Mountain View.

The above calculations depend critically on the estimated plume rise calculated from Brigg's expression (NOAA, 1983). The calculations used are empirically established, widely used, and generally accepted and although not specifically developed for the emission types dealt with in this analysis, there are no reasons to conclude that they are not appropriate, as no other alternative calculations are available according to Dr. Daniels. (Applicant's Exh. 11, p. 4 and 7).

g. The effective stack height is the sum of the physical stack height, and the plume rise due to buoyancy and momentum of the release gases as they exist in the cooling tower. (Applicant's Exhibit 11, p. 7).

h. From these calculations, the follwing maximum calculated concentrations of H_2S from a 55 MW plant for five downwind distances were determined as follows:

Distance Mile	Stability Class	Wind Speed mps	Eff. Stack Height, m	Concen. ppb
Power Production				
0.5	Neutral	20	37	4.2
1.0	Neutral	10	58	3.0
1.5	Neutral	10	58	2.4
2.0	Neutral	10	58	1.8
2.5	Stable	3	94	2.0
Stacking				
0.5	Neutral	20	33	4.0
1.0	Neutral	15	41	2.5
1.5	Neutral	10	56	1.9
2.0	Stable	5	79	1.4
2.5	Stable	3	92	1.6

(Applicant's Exhibit 11, p. 6).

i. Downwash of pollutants behind the cooling tower can occur during unstable conditions but will not cause high concentrations beyond property lines as the closest tower will be more than one mile from the boundaries. (Applicant's Exhibit 11, p. 7),

j. In the Dames and Moore (1984) report to the EPA, considerably higher concentrations were estimated using EPA models (MPTER and COMPLEX). These maxima occurred, however, with receptors located at elevations higher than the source and assuming that the pollutants did not follow the terrain contours but rather continued in a horizontal line to the receptor.

While this situation can occur in a valley during stable conditions with a source at the bottom and receptors along its sides, Dr. Daniels could not visualize a situation at the proposed geothermal area where this could happen. During drainage winds the pollutants will rise relative to the terrain as more cold air is produced at the ground while during trade winds and konas, stable conditions will not occur. (Applicant's Exhibit 11, p. 7).

k. Dr. Daniels concludes that for the proposed 55 MW plant downwind concentrations will not exceed 5 ppb beyond the property boundary during power plant operations or stacking when a discrete mean wind direction prevails. (Applicant's Exhibit 11, p. 8).

l. Dr. Daniels also made air quality calculations for stagnating wind conditions. (Applicant's Exhibit 11, p. 9).

m. As concentrations resulting from stacking were always lower than those from power plant operations only this type of emission was included this time in the calculations.

With cold drainage flow submerging the site, stability condition class E (stable) in the Pasquill-Gifford classification (Pasquill, 1974) was used. Though there is a more stable class, F, the plume rise is considerably higher for this class than class E. Therefore, in order to be more conservative, class E, which gives higher concentrations, was used. (Applicant's Exh. 11, p. 12 and 13).

As in the previous analyses for non-stagnant conditions, the commonly accepted Gaussian diffusion model was used. No surface reflection was again assumed as it seems likely that pollutants trapped in the vegetation layer will not be refloated under the modelled wind conditions. (Applicant's Exhibit 11, pp. 12 and 13.)

n. From these calculations, Dr. Daniels calculated the following concentrations of H_2S downwind of a 55 MW plant during stagnation periods:

Downwind Distance miles	Duration of Stagnation hours	Wind Speed During stagn., mps	Concentration ppb
1	4	3	8.4
2	4	3	8.3
3	4	2	7.6
4	4	2	6.7
5	4	2	5.7
6	4	2	4.8
1	8	2	10.6
2	8	2	10.6
3	8	2	9.8
4	8	1	8.7
5	8	1	8.0
6	8	1	7.1

(Applicant's Exhibit 11, p. 13)

o. Dr. Daniels concluded that concentrations above 15 ppb would never occur even during stagnant conditions from a 55 MW power plant located more than 1 mile from the property line during power plant operations - stacking.

Further, Dr. Daniels concluded that even in the very unlikely case that the emissions from two 55 MW plants would be in line with each other and the receptor, after an eight hour period of stagnation the concentrations would not exceed 30 ppb. (Applicant's Exhibit 11, p. 13-14).

p. James Morrow testified that if 98% abatement was used, even for stacking conditions, the 25 parts per billion standard would be met under his analysis (Testimony of James Morrow Vol. XIII, March 14, 1986, p. 28) and that he was aware that new power plants in California are being designed with a bypass system that allows a 98% efficiency to occur (Testimony of James Morrow, Vol. XIII, March 14, 1986, p. 29) and that the bypass system can be designed with redundancy in case the initial control system was not in proper function. (Testimony of James Morrow, Vol. XIII, March 14, 1986, p. 30).

2. Habitat, Quality and Biology

2.1 Data Derived on Habitat Quality and Biology

a. The area within and surrounding the geothermal development project area is rural, mostly forested with vegetation ranging from high quality native vegetation, with wet 'ohi'a forest with dense 80% canopy, to lower quality vegetation and open areas devastated by lava flows in and below the rift zone. Exotic plant species are found generally in all areas except the highest quality, closed canopy, native 'ohi'a forest. There is evidence that portions of the 'ohi'a forest in the northeast sector of the project area have been disturbed by human activity. (FSEIS, p. 30).

b. The lava ecosystem in the Kilauea East Rift Zone includes recent, barren flows as well as slightly older flows which support a pioneer vegetation. There have been several studies of plant succession on lava flows in Hawaii (Forbes 1912, Clements 1916, MacCaughey 1971, Robyns and Lamb 1939, Skottsberg 1941), however, the information from these studies is still only fragmentary. A few intensive studies of plant succession have been made at selected sites. Doty (1961, 1967) established several study plots on the 1955 lava flows. Smathers and Mueller-Dombois (1974) conducted intensive studies of succession on ash and pahoehoe at the 1959 Kilauea Iki eruption site.

The results of these studies show how diverse are the successional stages involved and how difficult it is to generalize effectively about succession on lava flows. The great range of environmental conditions available have produced a complex of successional stages.

From these studies it is clear that available moisture plays an important part in succession. Whether a lava flow occurs in a wet or dry locality will determine how rapidly plants are able to colonize it. In wetter areas, the development of vegetation is much more rapid. The whitish-gray lichen, _Stereocaulon vulcani_, often appears first on some lava flows, however, higher plants such as 'ohi'a (_Metrosideros collina_) and ferns such as swordfern (_Nephrolepis multiflora_) may also appear at the same time. "Ohi'a is the most common pioneer among the flowering plants and may even appear before the lichens. In dry localities colonization of lava flows is exceedingly slow. (State's Exh. 3, p. 7-8).

Lava flows of different ages and climatic exposures can be observed in the Kilauea East Rift Zone. The Pu'u O'o flows (1983 to present) are completely barren for they are too recent and, in fact, newer flows often pour over the earlier flows. (State's Exh. 3, pp. 7 and 8.)

2.2. Data on Flora in the Proposed Project Area

a. Existing Conditions

Results of three recent botanical surveys of Puna and the geothermal project area in particular (Jacobi 1985, and Char and Lamoureaux 1985a and 1985b), show that the area consists of a mosaic of different ecosystem types fragmented by recent lava flows (Figure 11, FSEIS). Much of these lands are covered by wet, pioneer community composed of scattered 'ohi'a trees and a dense tangle of uluhe ferns; rare or endangered species are usually not found in this vegetation type. 'Ohi'a (Metrosideros collina) forests of varying quality are found in the project area. Some of the existing forests of these lands have been affected by exotic plant species, feral pigs and cattle, and by human disturbances. Char and Lamoureaux (1985b) note that the ohia-a(1) and ohia'a(2) ecosystem types, which contain few exotic (introduced) plants, are the habitat for many rare and/or sensitive-to-disturbance plants as well as bird species. These two ecosystem types are generally found in the western half of the project area. The ohia-a(1) forests in the GRS are limited to three small stands primarily on the western border of the GRS and they are isolated by past lava flows. On the eastern end of the project area are lower quality 'ohi'a forests (ohia-b) with an understory layer dominated largely by exotic species such as Malabar melastome (*Melastoma malabathricum*), strawberry guava (*Psidium cattleianum*) and the introduced swordfern (*Nephrolepis multiflora*).

The high quality 'ohi'a forests [ohia-a(1)] were ground checked and correlated with Char and Lamoureaux's (1985a) vegetation maps and orthophotoquads. A walk-through survey method was used to identify the structure and composition of the plant communities. Species identification were made in the field. Plants which could not be positively identified were collected for later determination in the laboratory and herbarium.

The 'ohi'a forests of the project area can be divided into four different types based on structure, associated plant species, past and present disturbance, and the presence of exotic species. These four basic types are:

(i) Lava flows.

The most recent lava flows, still largely unvegetated, are those from the 1983-85 Pu'u O'o flows which are still unvegetated. There are also 1977 and 1955 lava flows which support early successional stages with scattered young 'ohi'a plants and a mixture of common native and introduced species.

(ii) _'Ohi'a-uluhe woodland_.

This is a forest which probably represents a later successional stage than (i) above. It consists of scattered 'ohi'a trees with an almost continuous carpet of uluhe fern. There are a few other native plants such as kopiko and 'uki. Introduced species such as malabar melastome and bamboo orchid are common.

(iii) _'Ohi'a forest types_.

These represent still later successional stages. Four such types were recognized:

(1) _Wet 'ohi'a forest with native species ('ohi'a-a(1))_.

These forests have tall 'ohi'a trees, usually more than 30 feet, with a nearly closed canopy. There is a subcanopy layer containing a number of native trees, and a third layer of hapu'u tree ferns, plus a ground cover of ferns and small shrubs. Very few introduced weeds occur here.

(2) _Wet 'ohi'a forest with native species and exotic shrubs ('ohi'a-a(2))_.

These forests differ from 'ohi'a-a(1) by containing a large number of introduced species in the shrub and subcanopy layers. Strawberry guava and malabar melastome are the major introduced species. The presence of these introduced plants indicates that these forests are more highly disturbed than 'ohi'a-a(1) forests.

(3) 'Ohi'a-kukui forest with mixed native and exotic shrubs ('ohi'a-a(3)).

This differs from 'ohi'a-a(2) by containing an admixture of the kukui, a tree introduced by the Polynesians. Other plants found here, such as 'awa and ti, suggest that these areas were probably utilized by the Hawaiians in former times.

(4) 'Ohi'a forest with exotic subcanopy and shrub layers ('ohi'a-b).

These are 'ohi'a forests which have been greatly disturbed in the past and in which the subcanopy layers consist largely of introduced species.

The 'ohi'a-a(1) forest is the most intact forest type, with the largest component of native species. It is the type which will be most sensitive to disturbance. (Applicant's Exh. 17, pp. 2-4.)

2.3 Data on Endangered, Threatened or Rare Plants

a. There are four identified plant species in the proposed geothermal development area which have been listed by the U.S. Fish and Wildlife Service in 1980 as either

Category 1 or Category 2 candidates listing as endangered species. Category 1 species are those for which the Service had on file substantial information on biological vulnerability and threat(s) to support the appropriateness of proposing to list them as endangered or threatened species. Presently, data are being gathered concerning the precise habitat needs and, for some of the taxa, concerning the precise boundaries for critical habitat designations. Category 2 species are those for which the Service had information indicating that proposing to list them as endangered or threatened species is probably appropriate but for which substantial data on biological vulnerability and threat(s) are not currently known or on file to support the immediate preparation of rules.

b. Figure 11 in the Final Supplemental EIS is a map which shows the distribution of ecosystem types in the Middle East Rift designated Geothermal Resource Subzone. Superimposed on this map is the proposed project exploration/development plan. The locations of four proposed endangered/threatened species are also indicated. The rare or endangered plant species identified in the project area are:

(1) Bobea timonioides or 'ahakea which occurs in the GRS, principally in 'ohi'a-a(1) and a(2) forests. It is uncommon except for one population in the northwest

portion of the subzone in 'ohi'a-a(l) forest. It is a Category 1 species. The locations of this plant found in the GRS are indicated as "Z" on figure 11 of the SEIS. (Applicant's Exhibit 17 p. 5.)

(2) Tetraplasandra hawaiiensis or 'ohe is a Category 2 species, which has in recent years been found growing widely throughout Puna as scattered individuals or small groups between 100 and 3,100 feet elevations. Its range is more extensive than previously believed and it is not currently considered to have a high priority for listing. (Applicant's Exhibit 17 pp. 5-6.)

(3) A fern, Adenophorus periens, is a Category 1 species. The principal remaining population is in the 'ohi'a-a(l) forest to the west and north of the GRS, in Kahauale'a and adjacent areas. One sighting of the plant, consisting of one clump on a single tree was made by the United States Fish and Wildlife Service during its Hawaii Forest Bird Survey in the project area (Jacobi, testimony at Nov. 15, 1985 contested case hearing). This locality has been designated by an "X" on figure 11 of the SEIS.

(4) Cyanea tritomantha or 'aku 'aku is also a Category 1 species. It was found in an area outside of the GRS in the northwest portion of the exchanged lands. While it may occur within the GRS, it was not found there during

the biotic surveys. Its location is designated by "Y" on figure 11 of the SEIS. (Applicant's Exh. 17, p. 6).

c. Other rare plant species found in the project area include lo'ulu (*Pritchardia beccariana*), maua (*Xylosma hawaiiense* Var. *hillibrandii*), nanu (*Gardenia remyi*) and kilioe (*Embelia pacifica*) (FSEIS p. 30).

d. The most sensitive areas in the proposed development area are those areas which have been categorized as ohia-a(1). The next most sensitive are at least parts of the forest characterized as ohia-a(2), as those are the two areas within which one is likely to find such things are rare and endangered species. (Lamoureaux, Vol. VI, November 15, 1985, pp. 101-102).

<u>2.4 Data on H_2S and Plants</u>.

a. Thompson and Kats did two season-long continuous fumigations of cultivated and native plants which grow near The Geysers, California, the largest geothermal energy producing area in the world. The plants studied were alfalfa (*Medicogo sativa L.*), Thompson seedless grapes (*Vitis vinifera*), lettuce (*Latuca sativa*), sugar beets (*beta vulgaris*), California buckeye (*Aesculus californica*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*) with serial dilutions of H_2S in greenhouses with 3,000 ppb, 300 ppb, 100 ppb, 30 ppb or 0 (control) levels. The highest levels of H_2S caused leaf injury, defoliation, reduced growth and death of the faster growing species, especially alfalfa and lettuce, and similar but less severe effects occurred with 300 ppb. The sugar beets, California buckeye, ponderosa pine and Douglas fir showed little effects at 300 ppb. With 30 ppb H_2S, lettuce, alfalfa, and especially sugar beets showed a pronounced stimulation of growth. Less effect occurred at 100 ppb. (Applicant's Ex. 9, p. 3, Thompson Tr. Vol. X, February 22, 1986, p. 94.)

b. A second study was done by Thompson, et al. (1982) to further determine if three major fruit crops, grapes, walnuts, and pears were being injured or had the potential for further injury from H_2S emitted by geothermal development near The Geysers, California. Hourly monitoring data of ambient H_2S levels were obtained from SRI International on seven sites near The Geysers. The site receiving the highest levels "Anderson Ridge" was selected as a model for test fumigation. In addition, three times these levels and amounts of SO_2 equivalent to these treble levels were used for exposures as follows: one-year old rooted cuttings of "White Riesling" and "Cabernet Sauvignon" grapevines, one-year old "Hartley" English walnuts on black walnut rootstocks, and one-year old "Bartlett" pear trees grafted on *Pyrus betulafolia* rootstocks were planted in pots with a soil mix of silt, sphagnum peatmoss, and perlite to which essential elements were added.

Eight separate greenhouses equipped with air conditioning, gas dispensing lines, air sampling lines, wet-dry bulb thermocouples, and irrigation systems were divided into 4 groups of 2 each. Group 1 received carbon-filtered air; group 2, carbon-filtered air plus simulated H_2S concentrations which occur near The Geysers at "Anderson Ridge," the location which receives the highest measured levels of ambient H_2S as recorded by SRI International; group 3, carbon-filtered air plus 3 times the Anderson Ridge levels; and group 4, carbon-filtered air plus amounts of SO_2 equivalent to H_2S in group 3.

The plants were grown from March 1, 1979 and fumigated for 24, 23, and 28 weeks for grapes, pears, and walnuts, respectively. In 1980, the fumigations were for 19, 15, and 17 weeks, respectively. No visible symptoms of injury occurred on foliage or other plant parts which could be attributed to treatment. None of the parameters measured on the 3 fruit species showed any statistically significant effects caused by the H_2S or SO_2 fumigations over the controls. (Applicant's Exh. 9, p. 4-5; Thompson, Tr. Vol. X, February 22, 1986, p. 94-96).

These studies show that fumigation in greenhouses for two growing seasons of 2 cultivars of grapes, and 1 cultivar each of pears and walnuts, which are grown widely near The Geysers are unaffected by the highest ambient levels of H_2S that occur in the area and also treble these levels or amounts of SO_2 equal to the threefold levels. (Applicant's Ex. 9, pp. 4-5, Thompson, Tr. Vol. X, February 22, 1986, pp. 94-96.)

c. These studies emphasize that effects of H_2S on vegetation depend to a great extent on the amount of the gas to which plants are exposed. If rapidly growing species receive high atmospheric levels continuously, injury occurs but if lower amounts are present, either no effect of a possible growth stimulation is noted. How the stimulation occurs is not known. Either an aerial fertilization effect or direct metabolic stimulation may be occurring. (Applicant's Ex. 9, pp. 5-6.)

d. Based on the results of these studies and Dr. Thompson's observation's of vegetation surrounding other geothermal developments, it was his opinion that H_2S at the levels anticipated in the project area would have no visible dilatorious effects of the native vegetation and in fact some growth stimulation may occur. (Applicant's Ex. 9, p. 7, Thompson, Tr. Vol. X, February 22, 1986, pp. 107-109.)

2.5 Data on Fauna in the Proposed Development Area

a. In 1979, the U.S. Fish and Wildlife Service conducted a census of native forest bird species found in the Puna Forest Reserve and the Wao Kele 'O Puna Natural Area Reserve. The information gathered from this survey was compiled in the Hawaii Forest Bird Recovery Plan which proposed those areas of essential habitat for four (4) native forest bird species. Figure 2 of VCA Exh. 7 shows the location of the transects used by the Service during its survey in the proposed development area. (VCA Exh. 7, Figure 2).

b. Based on the results of the Hawaii Forest Bird Survey and additional information received during the contested case hearing, seven endemic bird species have been sighted in the project area. These bird species are:

I'o, *Buteo solitarius*

Elepaio, *Chasiempis sanwichensis*

Omao, *Phaeornis obscurus*

Amakihi, *Hemignathus virens*

Apapane, *Himatione sanguinea*

Iiwi, *Vestiaria coccinea*

Pueo, *Asio Teammeus sandwichensis*

(FSEIS p. 54, Conant, February 18, 1986, Vol. II, pp. 23-24)

(i) I'o. Only one of these seven endemic species, the I'o or Hawaiian Hawk, is now classified as an endangered species. The distribution of the I'o is widespread, however, they are found to be a little more abundant in some areas of lower Puna. The I'o is also commonly found on the Kona Cost. It is a wide-ranging bird which has been found in areas of human disturbance which indicates it may not be as sensitive to human disturbance as other endemic Hawaiian birds. Although the I'o is fairly sensitive to disturbance at the nest site, its nests have never been found in the project area. (Conant, Tr. Vol. II, November 13, 1985, p. 71; Jacobi, Tr. Vol. V, November 15, 1985, p. 52; BLNR's DNO, Feb. 25, 1983, p. 4-37, FSEIS p. 54.)

(ii) Pueo. Another endemic species which may be seen in the project area is the Pueo or Hawaiian Short-eared Owl. The Pueo is a permanent resident on all main islands of the Hawaiian Chain. The birds occur from sea level to at least 8,000 feet on Mauna Loa and Mauna Kea. These birds are found to be tolerant of wide climatic conditions. The Pueo differs from most other owls in that it is diurnal in habit; hence, it is seen much more often than the nocturnal introduced Barn Owl (Tyto alba). While the Pueo is considered endangered on the Island of Oahu, it is not classified as endangered on the Island of Hawaii.

(State's Exh. 3, p. 74; Conant, Tr. Vol. II, November 13, 1985, p. 71, FSEIS p. 56.)

j. Sierra Club witness Conant stated that two (2) other species of birds, the A'o, or Newell's Manx Shearwater and the Ua'u or Dark Rumped Petrel, which are classified as a threatened and endangered species, respectively, may also use the project area. However, the only evidence found of A'o breeding near the proposed subzone parcel is at Makaopuhi Crater about 8 miles away where an adult A'o and an egg was found in 1972. The only large known nesting grounds for the Shearwater are on Kauai. No live colony of A'o has ever been found in the project area. There have been no reportings or sightings of this particular bird species flying over the project area. (Jacobi, Tr. Vol. II, November 13, 1985, pp. 147-148; Conant, Tr. Vol. II, February 18, 1986, pp. 53-54.)

k. Mammals known to inhabitat the project area include feral pigs (Sus scrofa), feral goats (Capra hircus), the small indian mongoose (Herpestes auropunctatus), roof or black rat (Rattus rattus), Norway rat (Rattus norvegicus), Polynesian rat (Rattus exulans), house mouse (Mus musculus), feral cat (Felis catus) and feral dog (Canis familiaris). (FSEIS p. 31.)

l. The only endemic land mammal in Hawaii is the Hawaiian Bat (Lasiurus cinereus semotus), a subspecies of the American hoary bat. There is no evidence of the occurence of this bat in the project area (Tomich, 1969). However, residents of nearby subdivisions have reported seeing bats (unidentified species) in or near the northeastern corner of the project area. (FSEIS, p. 31).

2.6 Data on Invertebrate Fauna in the Proposed Development Area

a. In the present major Hawaiian islands from Kauai to the Big Island, slightly more than 500 species of an endemic fruit fly, Hawaiian Drosophila, have been collected and described. In the University of Hawaii's collection are contained another 100 to 300 species of this fruit fly which are new and yet undescribed species. While Sierra Club's witness, Dr. Kaneshiro, thought there may be unique species of Drosophila which may be found in the project area, unique species of Drosophila have been found throughout all the major islands of Hawaii. (Kaneshiro, Vol. II, November 13, 1985, pp. 15-16, 30; Kaneshiro, Vol. I, February 18, 1986, p. 151).

b. In Dr. Kaneshiro's opinion, the genetic processes of evolution in terms of the Drosophila are not more dynamic in the rainforest habitat than in dry land habitats. However, the older the lava flow or the separation or the longer the separation of the species from each other, the more likely will be the chances of finding genetic differences, which is why Dr. Kaneshiro and his colleagues have studied the kipukas along the Saddle Road where the lava flows occurred about 100 years ago so that there's been a lot more time for differentiation to occur. (Kaneshiro, Vol. II, November 13, 1985, pp. 35-36, 40-41).

c. Although Dr. Kaneshiro's position was that as much of the development area as possible should be kept intact for future scientific research, Dr. Kaneshiro admitted that to date no such research has been conducted in that area due to a lack of funds and that he did not have such funds now to conduct any research there. (Kaneshiro, Vol. II, November 13, 1985, pp. 30-31).

d. Another invertebrate species which is found in the project area is the "Happy-face spider." This particular species of spider is found on all of the main Hawaiian islands other than Kauai. It is fairly widespread on the Big Island and while it is of interest to biologists, it is not an endangered species. (Kaneshiro, Tr. Vol. I, February 18, 1986, pp. 197-198).

2.7 Geothermal Impacts to Flora & Fauna

a. Geothermal development will include certain activities that create openings in the forest. These openings may result in alterations in the light, temperature, and the humidity regimes at the edges of the openings, leading to changes in the vegetation. The extent and nature of this edge effect may vary with the size of the areas cleared. (BLNR Decison and Order Baseline Findings 4.7.2.1 HA 3/2/82-1463).

b. Previously based on recent observations of old lava flows through the Kahauale'a parcel, Dr. Lamoureux had estimated that the edge effect would not be more than 50 to perhaps 100 feet in certain areas. However, a recent study by Lyndon Webster and J.O. Juvik suggests that the edge effect extends not more than ten feet beyond the edge of the road. Therefore, the effects of land clearing are not likely to extend much beyond the edge of the cleared lands. (BLNR's DNO, February 25, 1983, p. 5-7; Lamoureux, Tr. Vol. XI, February 23, 1986, p. 77 and 113).

c. The proposed development plans call for initial development to take place at sites A and B in the eastern part of the subzone in areas far removed from the most ecologically sensitive sites. The experience gained in these sites will permit any necessary modifications in mitigating measures to be made before development proceeds to the more sensitive site E in the northwest corner of the subzone. (Applicant's Exh. 17 p. 8.)

d. The actual amount of development which will occur in any single unit for the vegetation mosaic will result in the destruction or modification of only a small part of that unit, and should not interfere significantly with the successional and evolutionary roles of that unit. (Applicant's Exh. 17, p. 8).

e. To ensure that potential impacts on the vegetation and biological succession and mosaic pattern of that vegetation are minimized to the greatest extent practicable, well sites and power plants will <u>not</u> be located in the limited stands of ohia-a(1) forest. It is possible, however, that geothermal fluid pipelines and associated service roads may traverse ohia-a(1) areas. If this is required, botanical surveys will be conducted prior to construction to limit disturbances as much as practicable. In general, most well sites, power plants, service roads, etc., will be constructed in the ohia-a(2), ohia-b, ohia-uluhe and lava areas. For facilities sited in ohia-a(2) areas, botanical surveys will also be conducted prior to construction to avoid, whenever possible, the more sensitive portions of the forests. It is expected that it will be possible to avoid the more sensitive portions of the 'ohi'a forests based on the total land area of the GRS and the areas required by the project for various uses. Similarly, the following recommendations provided by Char & Lamoureaux (1985b) will also be followed:

-- Vegetation removal will be minimized and carefully limited only to that which is essential.

Sensitive areas will be inspected by qualified biologists before construction.

-- If areas in the Conservation Zone need to be revegetated, then only native species found in the area will be used. No exotic species will be brought into the area. (FSEIS pp. 50-51)

f. Dr. Kaneshiro agreed with the Applicant's recommendation to have qualified biologists conduct a survey of the invertebrate fauna in those areas to be developed prior to any clearing activities. Such a survey would minimize the affect of the proposed project on the invertebrate species found there. (Kaneshiro, Tr. Vol. I, February 18, 1986, pp. 146-148).

g. In terms of the Drosophila fruitfly in Dr. Kaneshiro's opinion it would be better to have the development project located on the lava flows instead of in the forest. (Kaneshiro, Tr. Vol. I, February 18, 1986, p. 198).

h. The noise from geothermal development may impact the fauna in the immediate area as studies have shown that animal behavior may be affected by excessive noise. The literature cites potentially negative effects from loud impulsive sounds, e.g. sonic boom; but none from the essentially continuous noise that animals will experience from geothermal operations. To date, levels of noise have not been identified to protect animals as has been done for humans. However, if further information is obtained which shows that farm animals or specific animal species protected by current law are being adversely affected due to noise levels from the project, then efforts will be made to reduce noise levels to mitigate the impacts on such animals. (Applicant's Exh. 12, p. 8-9).

3. Clearing and Access

a. The total land area to be cleared in construction of roads, drill sites, power plants, and transmission lines will be about 300 acres, approximately 1 percent of the total area of the land parcel in which the proposed project is planned. Development will not be concentrated in one site or in one flora community type, and will avoid, as far as possible, those areas of mature forest which are the most important sources of plants and animals for completion of the successional process. The dispersed nature of the development will mean that no single successional stage will be disturbed in more than a small percentage of the total area it occupies. (FSEIS p. 50).

b. The primary access road into the project area will be via State Road 130 to Pahoa By-Pass, North of Pahoa, to South Road and then to Middle Road in the Kaohe Homesteads (Figure 5 of the FSEIS). From the boundary of the state land, the access road would proceed to Exploration/Development Area "A" to the first drill site north of the center line of the rift zone. (FSEIS p. 16)

c. A secondary access road planned via State Road 130 to a county road approximately 3 miles south of Pahoa leading to the cinder pit south of Iilewa Crater. From the end of the county road, the access road into the state agricultural parcel (TMK 1-2-10:1) would proceed through AMFAC land (TMK 1-3-01:07), subject to the granting of an easement to Exploration/Development Area "B" on the south of the center line of the rift zone. An emergency exit road to the south from the center of the GRS (Exploration/Development Area "D") is planned for the route shown connecting with the western end of the county road leading to Route 130. (FSEIS pp. 16-17)

d. Service roads (20 ft. width) and transmission pipelines (adjacent to service roads in a 10-ft. corridor) will be constructed between wells and power plants. (FSEIS p. 16)

e. For planning purposes, five exploration/development (E/D) areas have been selected. Each area has three primary drilling sites planned (for a total of 15 sites) connected by access/service roads. Allowing for estimates of nonproducible wells, a total of 35 individual drilling sites within the five E/D areas may ultimately be required to produce 100 MW of electricity. The drilling sites will occupy from 2-3 acres. If directional drilling is technically and economically feasible, up to six exploration/development wells may be drilled from one or more drilling sites. (FSEIS p. 14)

f. Power plant sites will be located at a drilling site or within two miles of the furthest well site supplying steam to the plant. Pending successful well field development, five tentative power plant locations are shown in Figure 5. Power plants will vary in size from 5 MW to 55 MW. The area needed for a power plant will vary from 5 to 8 acres depending on the size/capacity of the plant.

g. The proposed project area presently is basically comprised of basalt rock, pahoehoe and aa lava flows, scrub growth with some forested areas (Tr. Vol. IV, February 19, 1986, p. 8; Applicant's Ex. 2, p. 2).

h. Although geologic hazards such as lava tubes and ground cracks are expected to be encountered in the construction of the road, Applicant's contractor has previous experience with dealing with such obstacles and does not believe there would be a problem in the construction of the road (Tr. Vol. IV, February 19, 1986, pp. 26, 31-32).

i. The initial access road from the Kaohe Homesteads entrance to E/D area up to drill site 3 has been validated by ground survey by Applicant's contractor (Tr. Vol. IV, February 19, 1986, pp. 9-10; Applicant's Ex. 2, p. 2). The estimated cost per mile for the construction of the road is from $50,000 to $60,000 (Tr. Vol. IV, p. 13). Based on the walkthrough survey and Applicant's contractor's knowledge and experience with building roads in the general area, it is possible and feasible to construct the necessary roads in the project area as designated on Applicant's development plan Exhibit 1-A (Tr. Vol. IV, February 19, 1986, p. 8, Applicant's Ex. 2, p. 2).

j. It is expected that between 10-15 construction workers will be needed in the building of the roads for the project area (Tr. Vol. IV, February 19, 1986, p. 29). Applicant's contractor foresees no problems with having a botanist in the field with the construction workers when the alignment is set for the network of roads (Tr. Vol. IV, February 19, 1986, p. 26).

4 Surface Waters

a. Geothermal development activities should not directly affect existing land uses since there are no known surface streams in the recommended area. (DOWALD Exh. 10,p.

12; BLNR Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

b. Following initial development of the geothermal resources, the production of potentially valuable associated geothermal products, demineralized water and mineral salts could have beneficial environmental consequences. (DOWALD Exh. 10, p. 12).

c. The normal disposal practice of geothermal fluids is expected to be reinjection, thus avoiding any adverse affects on surface water. (DOWALD Exh. 10, p. 12).

d. Discharge of geothermal fluids upon the land surface during limited well testing operations will not produce a detectable effect on groundwater resources in the Puna District due to the high recharge rate by meteoric water in the area estimated at 4.2 million gallons per day per square mile and the natural emissions of thermal fluids from the rift zone estimated to be 1.4 million gallons a day into the basal aquifer. Current experience at HGP-A indicates that surface disposal of 150,000 gallons per day of geothermal fluids over a period of one year has had a lesser impact on nearby groundwater quality than normal rainfall variations. (BLNR Decision and Order; Baseline Finding 4.1.3, CDUA No. HA 3/2/82-1463).

5. Groundwater Hydrology

a. The hydrology of the Puna District is not well established. The general hypothesis, as in other parts of the Hawaiian islands, is that the area is an underground lens of basal fresh water floating on salt water, with a relatively narrow band of dike - confined water (not floating on salt water) running across the southern part of the District, and with a coastal zone of brackish basal water west of Kalapana. Underlying the rift zone area, the groundwater would be brackish and warm or hot. (BLNR, Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

b. The groundwater resources of the Puna Distict occur in both confined and unconfined aquifers. The general theory is that the freshwater lens floats on salt water. This is based on the Ghyben-herzbeg concept which states that the lower density fresh water rests on the higher density salt water. The rule is that for each foot of fresh water above sea level, the fresh water extends 40 feet below. An allowance must be made for a mixing or transition zone. (BLNR Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

c. It appears that, in the Kilauea East Rift Zone, the hydrology is somewhat unique. The geothermal reservoir's thermal and permeability properties allow fluids to rise near the surface and to be mixed very rapidly through the geothermal system. In addition, as the result of vertical diking and fracturing that run east and west, there is high permeability in vertical and east-west directions; this causes damming or redirection of ground-water flow. A high head of water exists north of the rift zone, whereas to the south of the rift zone, the ground waters are at or near sea level. (BLNR Decision and Order; Baseline Finding 4.1.2, CDUA No. HA 3/2/82-1463).

d. Reinjection of plant effluent is planned for all power plants. The location and depth of reinjection zones will be determined prior to final development. In most fracture dominated reservoirs, the injected water travels downward until it is reheated. To take maximum advantage of the heat in the Rift Zone, injection is planned as deep as possible and as close to the center of the Rift Zone as possible. This plan also avoids the possibility of fresh water contamination. (Applicant's Exh. 18, pp. 8-9.)

6. Air Quality

6.1 Air Sampling Methods

a. There are several different air quality standards: The emission rate is defined as the compound that is emitted from a geothermal power plant measured at the point of discharge in terms of weight such as pounds, grams, or kilograms over a unit period of time. The ambient concentration of a particular emission is the amount per volume in the air in the environment outside the geothermal plant. The ambient air is what is breathed in the environment and the ambient concentration is the amount of a particular compound in the air being breathed.

b. Extensive baseline air quality monitoring has been conducted and air sampling has been taken over an area encompassing the entire Kilauea East Rift Zone extending from the summit of Kilauea Volcano to Cape Kumakahi. (Applicant's Exh. 4, p. 1).

c. Two years of baseline monitoring for the Kilauea Rift Zone area as a whole has been conducted by the State Department of Planning and Economic Development. One year of monitoring in and around the Kahauale'a geothermal project area has been conducted by the True/Mid-Pacific Geothermal Venture. One year of baseline monitoring has been conducted along the borders of the Hawaii Volcanoes National Park and Kahauale'a by the U.S. National park Service. (Applicant's Exh. 4, p. 1).

d. An air quality study was conducted by the True/Mid-Pacific Geothermal Venture which had monitoring stations within and adjacent to the proposed project area in the Kilauea Middle Rift Zone. This study was conducted to insure that the air quality within the present project area was consistent with the surrounding areas and that there was an absence of air quality peculiarities in the proposed project area. (Applicant's Exh. 4, p. 2).

e. Studies were made to assure that the air quality base taken for areas uprift and downrift of the Kilauea middle rift was relevant and applicable to assessing the air quality conditions in the middle rift. It was concluded that there was no difference in the air quality conditions in the middle rift from the upper and lower rift. (Testimony of James Houck, Vol. VII, November 21, 1986, p. 117.)

f. Based upon the extensive data sets generated by the baseline monitoring programs, miscellaneous previous scientific studies which have been published in the open literature, and environmental monitoring which has been conducted in relation to geothermal development in the Pohoiki Road area, the air quality in the proposed project area in the Kilauea Middle Rift Zone has been accurately described. (Applicant's Exh. 4, p. 2).

g. There is an overwhelming amount of environmental air quality data on the Kilauea East Rift Zone and there is adequate and sufficient data around the Kilauea Middle Rift Zone. (Testimony of James Houck, Vol. VII, November 21, 1986, p. 129, 130.)

h. U.S. Environmental protection agency guidelines pertaining to air quality sampling were followed except where technically appropriate refinements were made to monitor low concentrations of the air quality sample. U.S. EPA guidelines were followed regarding the selection and calibration of air quality monitoring instrumentation. (Testimony of James Houck, Vol. VII, November 21, 1986, p. 118).

i. The concentrations and characteristics of the key air quality parameters have been well documented in the air quality work. These findings are related to (a) atmospheric particles, (b) sulfur dioxide gas, (c) hydrogen sulfide gas, (d) rain water chemistry, (e) mercury vapor, and (f) radon activity. (Applicant's Exh. 4, p. 2).

Atmospheric Particles

j. The atmospheric concentration of particulate material is low in the project area as compared to mainland values and U.S. Environmental Protection Standards. (Applicant's Exh. 4, p. 2).

k. Total suspended particulate (TSP) values were calculated from over one hundred fifty high-volume samples collected at ten (10) locations along the Kilauea East Rift Zone over the course of two and one-half years. The values calculated were very low for all monitoring sites and was found to be less than two-tenths of the U.S. EPA standard for the monitoring site nearest the project area. (Applicant's Exh. 4, pp. 2, 3.)

l. Respirable and inhalable particulate concentrations are also low on the Kilauea East Rift Zone as compared to U.S. mainland values and the U.S. EPA standard for those particulates. Over fifty respirable and over fifty inhalable samples were collected and analyzed from two monitoring sites (Upper Lelani Subdivision and Volcano Village) over a year period. (Applicant's Exh. 4, p. 3).

m. The average respirable and inhalable values at the monitoring site nearest the proposed project area (Upper Leilani Subdivision) were approximately one-tenth (1/10) and three-tenths (3/10), respectively, of the average values obtained from seventeen non-urban mainland monitoring sites maintained by the U.S. EPA and the Electric Power Research Institute (EPRI). (Applicant's Exh. 4, p. 3).

n. In addition to high-volume total suspended particulates, respirable and inhalable samples, particulate material was also collected with low-volume and solar-powered equipment. Over four hundred such samples were collected and analyzed at twenty-three different sites along the Kilauea East Rift Zone during a two and one-half year period. The results obtained from the samples collected in and near the proposed project area were typical of samples collected along the rift zone in general. (Applicant's Exh. 4, p. 4).

o. The impacts of sea salt aerosols, geological material (dust and volcanic tephra), volcanic fume and phosphorus contained in organic compounds could be detected in the samples collected within the proposed project area. Particular samples collected nearer the ocean show a higher sea salt impact; samples collected near and/or downwind of volcanic vents show a higher volcanic impact; and those collected near roads show an impact due to vehicular exhaust. (Applicant's Exh. 4, p. 4).

p. The inorganic (geological material, volcanic fumes) content of samples collected on the Kilauea East Rift Zone is only a fraction of the total mass which is indicative of the high impact of organic compounds that originate from plant spores, pollen, vegetative fragments and combustion sources. Samples collected within the proposed project area reveal that on the average, 37% of the total particulate mass is from sea salt, 55% is from vegetative material, 5% is from dust and 3% is from volcanic sources. (Applicant's Exh. 4, p. 5-6).

q. The impact of volcanism and eruptions is episodic and overall annual means are not particularly illustrative in assessing the volcanic impact on air quality levels. During the nearly two and one-half years of baseline monitoring, there were 30 phases of the current Kilauea eruption series and a rare eruption of Mauna Loa. During the first year of the study conducted by the State Department of Planning and Economic Development, high and low volume samplers were simultaneously operated at a lower rift zone site (Upper Leilani Subdivision) and at an upper rift zone site (Hawaii Volcanoes National Park Visitor Center). By comparing the average values of samples taken during the active volcanism and during periods of no volcanic activity, it was concluded that volcanic activity did not significantly contribute to atmospheric particulate levels in the lower rift zone, but it did have an impact in the upper rift zone area. (Applicant's Exh. 4, p. 5.)

Sulfur Dioxide

r. Sulfur dioxide (SO_2) gas was considered as a high priority for baseline monitoring since it occurs at relatively high concentrations in volcanic fumes and is also produced by a number of industrial activities (Applicant's Exh. 4, p. 7)

s. Approximately 17,000 hours of continuous SO_2 monitoring has been conducted at eleven different locations and 132 integrated multi-day samples have been collected at ten locations along the Kilauea East Rift Zone. (Applicant's Exh. 4, p. 7).

t. During the majority of time, the atmospheric concentration of SO_2 in the proposed project area can be expected to be below several tenths of a parts per billion by volume (ppbv). (Applicant's Exh. 4, p. 7).

u. During the majority of time, the atmospheric concentration of SO_2 in the proposed project area can be expected to be below several tenths of a ppbv. However, during periods of vigorous volcanic activity, during periods of unusual meteorological conditions (winds from the southwest), episodic periods of high concentration may occur. Due to the short episodic nature of the high concentration SO_2 events, the U.S. EPA arithmetic annual mean (30 ppbv) is not likely to be approached in the proposed project area. While the U.S. EPA standard for SO_2 is never likely to be approached in the atmosphere above the proposed project area, the twenty-four hour standard (140 ppbv) may be, if volcanic and meteorological conditions are right. (Applicant's Exh. 4, p. 8.)

v. The Kilauea volcano normally (non-eruptive state) emits 200 tons a day of sulfur dioxide and the contribution of sulfur dioxide from the proposed project at full development would only be a fraction of 1 percent of the amount (BLNR Decision and Order: Baseline Finding 4.4.1.1, CDUA, No. HA 3/2/82-1463).

w. Acid rain is not only the result of hydrogen sulfide or sulfur dioxide emissions. Other emissions such as nitrogen oxides and halide acids are also necessary for acid rain to be produced. In comparing the biomass and the oil-fired plants, their emission rates in terms of grams per hour are far higher for sulfur oxides and nitrogen oxides under current new source performance standards than for geothermal emissions. (BLNR Decision and Order: Baseline Finding 4.4.1.1., CDUA No. HA 3/2/82-1463.)

x. The threat of production of acid rain from geothermal project operations and sulfur dioxide emissions can be controlled through the use of an abatement system developed by the DOW Chemical Corporation. The abatement system scrubs any sulfur dioxide produced in the process with an alkaline solution which is mixed with plant cooling tower water. Thus, no sulfur dioxide is released to the atmosphere. (Applicant's Exh. 18, p. 11).

Hydrogen Sulfide Gas

y. Hydrogen sulfide (H_2S) gas was considered as a high priority pollutant for baseline monitoring since it is the most problematic emission associated with the geothermal industry. It occurs at low concentrations in volcanic fume, and it can be produced biologically by anaerobic respiration. (Applicant's Exh. 4, p. 9).

z. During the baseline studies, approximately 17,000 hours of continuous H_2S monitoring have been conducted at eleven different locations, 132 integrated multi-day samples have been conducted at eleven different locations and 132 integrated multi-day samples have been collected at ten locations, and 275 passive H_2S monitors were placed at 36 locations along the Rift Zone. An extensive H_2S monitoring network has been maintained in the vicinity of the geothermal development area along the Pohoiki Road for a number of years (HGP-A). (Applicant's Exh. 4, p. 9).

aa. During the majority of the time, the atmospheric concentration of H_2S in the project area can be expected to be below several tenths of a ppbv. Very infrequently concentrations as high as 10 to 20 ppbv might be reached. As with SO_2, these high values would be due to the impact of volcanic fume and be episodic and short-lasting in nature. (Applicant's Exh. 4, p. 9).

bb. Occassionally, H_2S concentrations on the order of several ppbv may be reached in the project area due to anaerobic respiration. Water-logged, organic-rich soils such as occur in the Puna district make ideal conditions for the production of H_2S by anaerobic respiration. To the north of Pahoa, a large relatively recent pahoehoe flat is located. During the monitoring, which was conducted in and adjacent to the proposed project area, low-level concentrations of H_2S ostensibly from anaerobic respiration were measured on this pahoehoe flat. This area is very extensive and is upwind of the project area under normal trade wind conditions. (Applicant's Exh. 4, p. 8, 9).

cc. However, it should be emphasized that based on the results of multi-day samples and the 275 passive monitors, hourly means H_2S values are not likely to exceed the several tenths to several ppbv levels due to natural sources (either volcanic or biological), and standard values such as the one hour California state standard of 100 ppbv will never be approached. (Applicant's Exh. 4, p. 9).

dd. The results of the baseline air quality studies along the Kilauea East Rift Zone show that in most places, the ambient concentration of hydrogen sulfide is less than 0.5 parts per billion and any geothermal development activities would not be adding to a large existing concentration of natural hydrogen sulfide. (Testimony of James Houck, Tr. Vol. VII, November 21, 1986, p. 127.)

Mercury Vapor

ee. Numerous mercury vapor measurements have been made on the Rift Zone. Reported total mercury vapor (elemental, organometallic, and halide) values typically range from several ng/m^3 to several hundred ng/m^3. Temporal, spatial, and analytical differences are probably responsible for the range in values. (Applicant's Exh. 4, p. 13).

ff. Two opposing factors control mercury vapor on the Kilauea East Rift Zone. The unpolluted atmosphere above the open ocean (i.e., trade winds) have a very low mercury content (few tenths to one ng/m^3). Volcanic fume, on the other hand, can contain hundreds to tens of thousands of ng/m^3 of mercury. The degree of volcanic activity, the location of a given sampling site with respect to vents and/or geological features, and the meteorological conditions during sample collection can all alter the observed atmospheric mercury concentration. It should also be emphasized that the measurement of any gas to the nanogram per cubic meter range should be viewed cautiously, and the values reported should probably be considered order of magnitude values at best. (Applicant's Exh. 4, p. 13).

gg. The site specific average values for 56 mercury samples collected at nine locations during the environmental baseline studies conducted on the Rift Zone between February 1984 and March 1985 ranged from 3 to 7 ng/m^3. The range of values obtained from 463 samples collected between 1977 and 1982, Siegel, B.Z. and Siegel, S.M., (Baseline Mercury Levels in Puna District, Hawaii

County, Report to Hawaii Natural Energy Institute, 1984, p. 39) along highway 11 from Kea'au to Volcano Village was from 50 to 200 ng/m^3. The degree to which the differences between the two data sets are due to temporal and spatial effects and the degree to which the differences are related to analytical methodologies cannot be determined at this time. The combined data sets illustrate the range of mercury values which can be reasonably be expected in the atmosphere above the project area and clearly show that these levels are dramatically lower than occupational Safety and Health Administration (OSHA) work place maximum level is 100,000 ng/m^3. (Applicant's Exh. 4, pp. 14, 15).

gg. Ten elemental mercury vapor samples were also collected along the Kilauea East Rift Zone during 1983. The range of values was 4 to 45 ng/m^3, which falls between the typical values for the two total mercury vapor data sets. (Applicant's Exh. 4, p. 15).

hh. It has been suggested that mercury halides (chlorides and fluorides) constitute the largest fraction of atmospheric mercury vapor. This seems unlikely as the mercury content of over six hundred particulate samples were measured by x-ray fluorescence spectrometry, and the highest value ever measured along the Rift Zone was 4 ng/m^3. (Applicant's Exh. 4, p. 15)

ii. Atmospheric mercury concentrations can be expected to very low above the proposed project area and dramatically below standard values. There is some disagreement as to the absolute atmospheric concentration level and the chemical form of the mercury primarily due to the very fact that its atmospheric concentration is so low as to cause it to be difficult to measure accurately. (Applicant's Exh. 4, p. 16).

jj. Whether mercury poses a toxic hazard or not must be considered and given a perspective in relation to the natural background levels of that element. Soil levels can be in the range of 30 to 90 ppb (parts per billion) and rain water 0.1 to 0.3 micrograms per liter. The levels of less than 0.1 microgram per liters in the geothermal brines are in fact local background levels. Additionally, mercury is not expected to be found in any detectable amounts from the cooling towers. (BLNR Decision and Order: Baseline Finding 4.4.1.1., CDUA No. HA 3/2/82-1463.)

Radon Activity

kk. Radon-222 is a radioactive gas naturally formed from the decay of radium contained in geological materials. Radon-222 has a 3.8 day half-life and decays via an energetic alpha particle. Two of its daughter products (Polonium-218 and Polonium-214) also have very short half lives (3.0 minutes and 1.6 x 10-4 seconds respectfully), and also decay by energetic alpha particles. (Applicant's Exh. 4, pp. 16, 17).

ll. Due to the radioactivity of Radon-222 and its daughter products, and the fact that Radon-222 is a gas which can be inhaled, high Radon-222 concentrations are injurious to human health. (Applicant's Exh. 4, pp. 16, 17).

mm. Two opposing factors control the atmospheric radon content in the proposed project area. High radon emission rates are associated with volcanic areas. Conversely, air above the open oceans such as constitutes the trade winds, has a very low radon activity (estimated 10 pCi/m^3). (Applicant's Exh. 4, p. 17).

nn. A total of fifty-eight passive radon monitors were located at sixteen different sites along the Kilauea East Rift Zone during the two and one-half years of baseline monitoring. (Applicant's Exh. 4, p. 17).

oo. The typical radon activities characteristics of the Kilauea Middle Rift Zone are between less than a tenth to approximately a sixth of the California standard of 3,000 pCi/m^3. The values within the proposed project area appear to be representative of the Kilauea East Rift Zone in general. (Applicant's Exh. 4, p. 19).

pp. Radon exists in the reservoir at The Geysers geothermal area and when the steam comes out of the reservoir, it sweeps the radon along into the power plant conversion and abatement system. Radon follows the non-condensable gases through the hydrogen sulfide abatement system and is then vented through the cooling tower and is mixed with a much larger volume of atmosphere. The mixing of the small volume of radon with a large volume of air that goes through the cooling tower causes the radon to not accumulate in the environment but to maintain a constant level as an equilibrium in which the concentration stabilizes. Equilibrium means a state of constant quantity where the amount of formulation and the amount of decay or destruction of the radon are equal so that a constant amount is maintained at any one time. (BLNR Decision and Order: Baseline Finding 4.4.1.1., CDUA No. HA 3/2/82-1463.)

Boron

qq. No substantial amounts of boron appear in the ambient air. In the case of geothermal development, boron would not be released to the air, but would stay in the liquid phase at the abatement system separator and be returned to the steamfield and would not go through the turbine where it could be released into the atmosphere. Boron would be reinjected and under proper precautions, would not escape during the reinjection. (BLNR Decision and Order: Baseline Finding 4.4.1.1., CDUA No. HA 3/2/82-1463.)

Rain Water Chemistry

ss. The chemical composition of rain water is an important parameter to examine on the Kilauea East Rift Zone for three primary reasons: (1) rain "scrubs" the atmosphere of pollutants and by doing so, becomes contaminated with them, (2) acid gases and mists emitted by volcanoes will produce "acid rain," the deleterious impact of which is a topical issue, and (3) many residents along the middle rift zone use rain water catchment as a source of drinking water. (Applicant's Exh. 4, p. 10).

ss. During the period from December 1982 through March 1985, some fifty-five rain water samples were collected and analyzed for the various environmental baseline studies which were being conducted. In addition, some catchment water in the vicinity of the geothermal development areas along Pohoiki Road has been tested and several scientific studies have examined the rain water chemistry on the Island of Hawaii. (Applicant's Exh. 4, p. 11).

tt. Three major factors influence rain water chemistry along the rift zone: (1) all rainfall in Hawaii has the tendency to be slightly acidic due to the long range transport of pollutants from industrialized mainland areas,

(2) volcanic fume locally acidifies rain and impacts its chemical composition, and (3) sea salt aerosols make rain less acidic due to their bicarbonate content and also impact the chemical composition of the rain. Calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), strontium (Sr), chloride (Cl^-), and sulfate (SO^{2-}) are major constituents of sea salt and are the principal chemical species seen in rain water samples collected within the proposed project area. Aluminum (Al), calcium, iron (Fe), manganese (Mn), potassium, and silicon (Si) are major constituents of geological material such as comprises volcanic tephra. Sulfate, chloride, and fluoride (F^-) are contained in volcanic fume. The elements and anions associated with volcanic fume and tephra have been seen in samples collected downwind of volcanic vents (e.g., along the Chain of Craters Road downwind of Pu'u O'o). (Applicant's Exh. 4, p. 11).)

uu. The impact of sea salt is elevation-dependent on the Island of Hawaii. Using the sodium concentration measured in samples collected for the baseline studies and in samples collected in a previous study (Simpson, H.J., 1972, Aerosol Cotiens at Mauna Loa Observatory, J. Geophys. Res., V. 77, p. 5266 - 5277), the decrease in the impact of sea salt with elevation was graphically illustrated. Rainfall collected at the elevations found in the proposed project area has a clear sea salt component, with the lower elevations having a larger impact than the higher elevations. (Applicant's Exh. 4, p. 11).

vv. The impact due to volcanism is also elevation-dependent mainly because the major volcanic vents and fumaroles are above 2,000 feet. Using pH as an indicator of volcanic impact, the large increase in volcanic impact at about that elevations and above could be concluded from the sampling. Based on the data collected along the Kilauea East Rift Zone, rainfall in the very highest elevation portions of the proposed project area should show the impact of volcanism both in its chemical composition and pH. However, in regards to the volcanic impact on rain water chemistry, the same caveat must be considered as with the volcanic impact seen in atmospheric particles and gas. Under unusual meteorological conditions, during periods of very active volcanism, the regions which are affected by the volcanic pollutants will change. (Applicant's Exh. 4, p. 11).

6.2 Geothermal Gas or Steam Emissions Data

a. Determinations of the exact nature of the geothermal gas or steam emissions expected to be released into the atmosphere is a product of (1) the current ambient air levels, (2) the effect of various monitoring and abatement programs, (3) the size and nature of geothermal production operations, and (4) the relative presence or absence of volcanic emissions occurring naturally in the project area. (BLNR Decision and Order, Baseline Findings 4.4.2.1 CDUA HA 3/2/82-1463).

b. How effective the various monitoring and abatement programs will be is a function of the size and nature of the geothermal operations, the composition of the geothermal fluids, the state of the technology, and many related factors. (BLNR Decision and Order, Baseline Findings 4.4.2.1 CDUA HA 3/2/82-1463).

c. The gas or steam phase from a geothermal well will contain carbon dioxide, hydrogen sulfide, nitrogen, hydrogen and traces of several other gases including radon. Of these, concern has been expressed about the hydrogen sulfide and radon. RADON: The amount of radon in the reservoir fluid from HGP-A is 1.82 nanocuries per kilogram of steam, or 1,820 picocuries per liter. (BLNR Decision and Order Baseline Findings 4.4.2.1 CDUA HA 3/2/82-1463).

d. HYDROGEN SULFIDE-STANDARDS:

(i) Currently, the State's Department of Health Ambient Air Quality Regulations do not set standards for hydrogen sulfide and mercury. California's ambient standard for hydrogen sulfide is .03 ppm. There was testimony that most states and countries around the world have stricter standards for hydrogen sulfide compared with

California's or Campbell's proposed standard of .03 ppm. The Air Quality Advisory Commission's report to the Department of Health suggests an ambient air quality standard for hydrogen sulfide of .1 ppm, one hour average. It also recommends that no degradation of existing air quality exceed .025 ppm above current baseline levels. (BLNR Decision And Order: Baseline Finding 4.4.2.1 CDUA No. HA 3/2/82-1463.)

(ii) Some foreign countries have established more stringent hydrogen sulfide standards, but they are never enforced. They are probably not worth the paper they were written on. It looks good politically for them to do so. (Testimony of Bruce S. Anderson, Vol. VI, February 20, 1986, p. 73).

(iii) Mr. James Morrow is satisfied with the proposed H_2S standards proposed to the Department of Health as they are fair and can be lived with by both the developers and surrounding communities. (Testimony of James Morrow, Vol. VI, February 20, 1986, p. 118.)

(iv) According to James Morrow, the proposed standards for H_2S are pretty stringent standards and if followed, there will not be too much of an odor problem. (Testimony of James Morrow, Vol. VI, February 20, 1986, p. 140).

6.3 Consequences of Air and Toxicology Data and Methods

a. The emissions of sulfur, mercury, and other volcanic gases are a continuous process at Kilauea, the rift zone, and the adjacent forest and its inhabitants have long been exposed to lower levels of these potentially toxic emissions and intermittently to higher levels. Exposure to significant levels of geothermal gases are part of the norm for native Hawaiian plants and animals. (CDUA Baseline Findings 4.4.3. HA 3/2/82-1463).

b. The most important factors relevant to potential impacts arising from the production of geothermal fluids include the volumes of geothermal fluids being produced; the existing and projected ambient levels of the components to be released; the dose/response characteristics of potential receptors of the emissions, the duration of exposure to the toxicants; and natural emission or loading rates of the individual components. (CDUA Baseline Findings 4.4.3. HA 3/2/82-1463).

c. A report recently prepared for the U.S. Environmental Protection Agency, Evaluation of Bact for and Air Quality Impact of Potential Geothermal Development in Hawaii, analyzes most available H_2S abatement systems. These include iron catalyst primary system; the iron catalyst secondary system; the hydrogen peroxide, caustic, iron catalyst (HPCC) primary system; burner-scrubber system;

and the Stretford system. The report recommends the Stretford system as the primary on-line abatement system. This system can remove over 99% of the H_2S contained in the noncondensable gases. By-products of the Stretford system include marketable elemental sulfur and sludge which requires disposal. (DOWALD Exh. 11, p. 4-5; KGS 8/27/84).

d. A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement sytems can be utilized in the event the plant is "down" for maintenance or emergency. If maintenance is required on either the turbine or generator, the geothermal steam can be routed directly into the condenser utilizing the primary abatement systems. Since the turbine does not dissipate any heat or energy in the bypass mode, the cooling system must be over-designed to accomodate the extra heat during "turbine bypass." If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal. In emergencies, well throttling may be accomplished by manual valve turndown or automatic valve control. Throttling must be slow (at least 15 minutes) and can reduce the flow to a fraction of the well's maximum flow rate. The degree of throttling possible will depend upon the characteristics of each well. However, there is a danger that the additional stress with increased pressure could damage the well-bore, casing, or well-head equipment. If a geothermal development has more than one power plant, the wells could be moderately throttled and diverted to an operating plant. If all the above continency abatement options are not available, a geothermal well may have to be free vented through a silencer without H_2S abatement until the required maintenance is completed or such time as the well can be shut-in completely. (DOWALD Exh. 11, p. 5; KGS 8/27/84).

e. The abated gases, condensate, and warm water are circulated through the cooling tower. Cooled water from the cooling tower is recirculated through the condenser; any excess water (blowdown) is piped into an injection well. It is expected that a wet, mechanical draft, cooling tower will be applied to geothermal development. Warm water enters the tower near the top, while a fan forces air through slats designed to maximize the surface area of the falling warm water. Use of drift eliminators significantly reduces the chance that any water droplets will exit with the steam plume. This falling water also scrubs any particulates from the gas exiting the abatement system. At "The Geysers" geothermal development in California, small amounts of boron from the condensate has been emitted with cooling tower drift (small water droplets entrained in the steam plume) having some advese effects on nearby vegetation. Based on the characteristics of the HGP-A reservoir fluids and the emissions from Hawaii's geothermal resources should not be toxic to flora and fauna in the vicinity of the geothermal power plant. Data available from the HGP-A indicates the plume from the cooling tower should consist entirely of water vapor. The proposed DOH regulations require 98% H_2S abatement and a concentration of no greater than 25 parts per billion H_2S at the property line of a development. (DOWALD Exh. 11, p. 5-6; KGS 8/27/84).

f. In addition to cooling tower blowdown, brine leaving the separator will be piped into the injection well. If the rate of silica deposition in the brine is high, a silica-dropout system will be utilized between the steam-brine separator and the injection well. Otherwise, silica deposition within the injection well might cause it to become plugged. The silica deposits will be removed periodically and disposed of in an acceptable manner (DOWALD Exh. 11, pp. 4-6; KGS 8/27/84).

g. Most power plants being constructed today contain three basic abatement features: a primary system, a secondary system and a bypass system. Selection of the optimum method is highly dependent on the resource composition. Certain methods are not easily adaptable to fluctuating process streams while others create byproducts that present disposal problems. The current trend is toward the eliminating the transportation and disposal of hazardous wastes. (Applicant's Exh. 18, p. 10).

h. For applications in Hawaii, a modern abatement control design will be considered to meet the air quality standards. New improvements in burner-scrubber technology have moved this paticular H_2S abatement system to the forefront. Power plants in The Geysers are being tested for possible retrofitting with this system rather than the Stretford or caustic/hydrogen peroxide systems (Dorighi, 1984). The burner-scrubber process is more effective when combustible gases such as H_2S are present and takes up less space than the Stretford system. Moderate H_2S helps the system by providing fuel. Currently, Dow Chemical markets the equipment under the trade name Gas/Spec RT-2. Their technical data claims that high levels of abatement, as high as 99.99% can be achieved. Heretofore, burner-scrubber processes were considered to be less reliable and less efficient than the Stretford process. The main improvement comes from carefully controlling the combustion in an alkaline environment. Noncondensible gases extracted from the condenser is incinerated. The SO_2 produced by the burning is scrubbed with an alkaline solution and mixed with plant cooling water. Thus, no threat of acid rain is presented. The cooling tower water and scrubber water are then treated with iron chelate which converts the sulfur compounds in the water into a thiosulfate form that is highly soluble in water. The overall system provides abatement efficiencies equivalent to the Stretford but eliminates solid waste. The burner-scrubber, however, is sensitive to interruptions in fuel supply. This can be remedied with a propane pilot light. The Dow process also avoids the biggest drawback to the Stretford system, the generation of elemental sulfur and vanadium pentoxide. Dow is currently testing their system at HGP-A. Preliminary results indicate that improved abatement is being observed at lower cost. (Applicant's Exh. 18, pp. 10, 12.)

i. In terms of secondary abatement, an iron chelate system is used. This is the same method as injecting caustic soda except that iron chelate is used rather than caustic. Iron chelate is nonhazardous and commonly used as a plant fertilizer to "green-up" plants. (Applicant's Exh. 18, p. 12.)

j. For turbine bypass systems, the steam is passed directly to the condenser and then the noncondensible gases are removed to the primary abatement system. An oversized condenser is required, bu the bypass arrangement removes one of the largest sources of H_2S emissions. (Applicant's Exh. 18, p. 12.)

k. A final decision on power plant design cannot be made until after extensive well testing is completed and representative resource composition data is collected. (Applicant's Exh. 18, p. 12.)

During drilling and well testing, H_2S abatement might have to be conducted depending on the resource characteristics. Currently the caustic injection abatement method is used. An extension of the iron chelate technology, currently being tested in the Geysers power plant is being tested in drilling and well testing operations. It has the potential to be in wide use in a few months if preliminary results are representative. This process is safer and provides better, more consistent abatement, at lower cost. (Applicant's Exh. 18, p. 12-13).

H. Historic and Archaeological Value of the Proposed Site

1. In October and November, 1985, PHRI conducted preliminary archaeological reconnaissance survey field work within the proposed geothermal development area in the Wao Kele O Puna Natural Area Reserve, Puna District, Island of Hawaii (Haun, Rosendahl, and Landrum 1985; PHRI Report 205-110985). Ground inspection reconnaissance field work was carried out on October 31, and November 1, 5, and 13, 1985 and was supplemented by aerial reconnassiance (by helicopter) on November 18, 1985. (Applicant's Exh. 8 p. 2)

2. The preliminary archaeological reconnaissance survey was conducted to sample several areas adjacent to and within portions of the geothermal resource subzone and development area. The objectives of the survey were to (1) supplement the historical and archaeological documentary research for this area in order to provide a general assessment of the likelihood of the presence and general nature of any remains of any sites or features of possible archaeological significance within the project site and (2) to provide a basis for conducting the full reconnaissance surveys when final site selection for each project facility is made as the project progresses. (Applicant's Exh. 8 p. 2-3)

3. The aerial reconnaissance by helicopter did not reveal the presence of any definite archaeological remains. However, three sightings were made of banana plants growing within small lava sinkholes in forested areas. The presence of bananas as a cultigen indicator suggests intentional agricultural utilization of the immediate area in the past. (Applicant's Exh. 8 p. 5)

4. The ground inspection field work in the two areas reached by helicopter did not reveal the presence of any archaeological remains. These results support the indications from Transects 1 through 5 that most archaeological remains to be found within the project area

would probably be relatively sparse in density, tenuous in nature, and difficult to recognize with certainty. (Applicant's Exh. 8, p. 5)

5. From Dr. Rosendahl's review of available archaeological, ethnographic and historical information, one final general observation can be made regarding the apparent distribution of archaeological remains within and adjacent to the present project area. In southwestern Puna, archaeological remains are concentrated within the immediate coastal zone and, for the most part, tend to decline rapidly in both variety and density as one progresses inland. Archaeological and documentary evidence for aboriginal patterns of inland habitation and exploitation--principally dryland agricultural activities and associated short-term residential occupation within the lower reaches of the forest--indicates that the density of archaeological remains decreases quite rapidly in the vicinity of the southern periphery of the proposed geothermal development area. Thaerefore, it would seem reasonable to suggest that, with one exception, any archaeological remains present within most of the project area would be widely scattered, as well as physically tenuous. The one exception might be a slightly higher density of remains along the routes of major

trails that passed through the inland forest. (Applicant's Exh. 8, p. 5-6)

6. Potential impacts to the historical/archaeological attributes of the project area include the disturbance or destruction of sites with potential historical or archaeological significance. To ensure that these potential impacts are minimized to the greatest extent practicable, a full archaeological reconnaissance survey has been committed to by the developer for any area selected to be cleared for project operations, prior to the initiation of clearing operations. (Applicant's Exh. 8, p. 6)

7. The basic objective of the full reconnaissance survey would be to identify and evaluate sites and features of potential archaeological significance present within the areas to be cleared. The full reconnaissance survey should be conducted in accordance with the standards for reconnaissance level survey recommended by the Society for Hawaiian Archaeology (SHA). These standards are currently being used by the Hawaii County Planning Department and the Hawaii State Department of Land and Natural Resources - Historic Sites Section as guidelines for the review and evaluation of archaeological reconnaissance survey reports submitted in conjunction with various development permit applications. (Applicant's Exh. 8, p. 6-7)

8. The apropriate areas to be surveyed include the proposed access corridors, drill sites, power plant sites, and any other areas to be impacted by construction activities. These areas will be clearly marked on-the-ground prior to archaeological field work. The survey areas will also include sufficient buffer zones--perhaps two to five or more times larger than the actual extent of the access road corridors, drill sites, power plant sites, and any other development areas--to insure that any archaeological resources in the immediate vicinity, but not actually within a specific area to be impacted will not be inadvertently damaged by construction activities. The buffer area should also insure that the full context of archaeological remains within the specific impact areas will be determined (e.g., the full significance of a seemingly isolated structure cannot be accurately determined if it is part of a larger, but unidentified, complex of structures). (Applicant's Exh. 8, p. 7-8)

9. Based on the results of the full reconnaissance survey findings, the level of appropriate further archaeological work could be determined. Such further work could include intensive survey--detailed recording of sites and features, and controlled test excavations; and possble subsequent mitigation--salvage or research excavations, interpretive planning, and/or

preservation of sites and features with significant scientific research, interpretive, and/or cultural values. (Applicant's Exh. 8, p. 8)

10. An archaeological research design to guide all future archaeological work within the project area will be formulated. A research design is a plan for conducting an archaeological investigation. It includes a statement of both general and specific research objectives, specifies the data necessary to address the objectives, and describes the strategies and methods to be utilized for data recovery. (Applicant's Exh. 8, p. 8)

11. Because of the extensive nature of both the proposed geothermal development area and the proposed construction activities, a sampling strategy for data recovery which is based on proposed development areas can potentially provide a valuable data base that will not only serve immediate development planning needs, but will also facilitate any future development planning and made a substantive contribution to archaeological knowledge about the area. (Applicant's Exh. 8, p. 9)

I. ECONOMIC FEASIBILITY OF PROPOSED PROJECT

a. Dan Williamson, President of Hawaiian Electric Company, did a rough economic analysis of the economic feasibility of the proposed geothermal project. Mr.

Williamson's evaluation showed that the projected Annual Plant Carrying cost for a geothermal plant would be 4.77 cents/kwh compared to HELCO's avoided cost of 6.70 cents/kwh. (Applicant's Exh. 14(a); Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 80).

b. The carrying cost of the undersea cable was estimated at 1.65 cents/kwh (Applicant's Exh. 14(a)) and was conservative as it took the higher end of the estimated total cost of the undersea cable of $400 million rather than the lower estimate of $200 million. (Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 80)

c. Under Mr. Williamson's analysis, when all the numbers are totalled up the cost for geothermal electricity delivered to Oahu was estimated at 6.42 cents/kwh which is less than HECO's avoided cost of 6.68 cents/kwh. (Williamson, Tr. Vol. IX, February 22, 1986, p. 82 and 84).

d. Dr. Plasch has reviewed a number of calculations that were done by the State of Hawaii regarding the combined feasibility of geothermal power, and an undersea transmission cable. Indications are that both can be profitable. (Testimony of Bruce Plasch, Vol. XIII, March 14, 1986, p. 173)

e. Another reason for expecting a geothermal plant to be profitable is that it is a proven technology. There are over 150 geothermal power plants in the world and a number of these were built in 1973 when the price of oil was very, very low. With higher oil prices, it makes the profitability even better. (Testimony of Bruce Plasch, Vol. XIII, March 14, 1986, p. 179 and 180).

f. Assuming a figure of $2,000.00 per kilowatt of installed capacity for a geothermal power plant, and the cost of putting in an oil fired electric plant which is just slightly less than that, about $1,800.00, and does not have the same energy credits as the geothermal, the capital cost per kilowatt of installed capacity is about the same for the two sources. With one you have to import very expensive oil and the other you don't, and there's just no question that geothermal power is going to come out much cheaper than going with oil fired power. (Testimony of Bruce Plasch, Vol. XIII, March 14, 1986, p. 180-181).

g. Although Dr. Robert McKusick testified that he would give a very low probability that geothermal power could be delivered to Oahu for less than the avoided cost, he admitted that he did not have sufficient information to make an economic feasibility study that he would be satisfied with. (Testimony of Robert McKusick, Vol. XIII, March 14, 1986, p. 133)

h. Dr. Robert McKusick's analysis used figures for maintenance that George Jenkins used which were based on a demonstration well and to which Dr. Plasch believes provide no useful guidance whatsoever on maintenance costs. (Testimony of Bruce Plasch, Vol. XIII, March 14, 1986, p. 203)

i. That the WPPSS project that Dr. McKusick used to compare with the present project was for a much larger scale involving 5 power plants at an estimated cost of $4-$5 billion, which were each designed to produce approximately 1011 megawatts of electricity. (Testimony of Robert McKusick, Vol. XIII, March 14, 1986, p. 122-123)

j. That the WPPSS project was financed by floating revenue bonds and by guaranteed sales to retail utilities. However, electric consumers of the State of Hawaii will not be economically hurt by this development as they are paying monies for the drilling of the wells and will not be developing a plant that may fail or be uneconomical. (Testimony of Robert McKusick, Vol. XIII, March 14, 1986, p. 124; Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 128)

k. Hawaiian Electric forecasts that on the average a midrange estimation is that oil prices are going to be flat at about $29 a barrel through 1990. (Testimony of Dan Williamson, Vol. IX, February 22, 1986, p. 96)

J. Geothermal Resource Subzone Guidelines.

1.1 Compatibility with Present and Planned Use

a. The KMERZ/GRS is located in the Wao Kele 'O Puna Natural Area Reserve.

b. Conservation districts include lands necessary for protecting watersheds and water sources; lands susceptible to floods, soil erosion, inundation by tsunamis and volcanic activity and landslides; lands used for parklands, beaches and the preservation of scenic, historic or archaeological sites; lands below the zone of wave action; lands with a general slope of 20% or more; lands with topography, soils, or climate not presently needed or normally adaptable for urban, agricultural or rural uses; and lands suitable for farming, nurseries, flower gardening, growing of commercial timber, grazing, hunting and recreation. (State Land Use District Regulations, Part II, Section 2-2(3)).

c. The project is located within a volcanic rift zone marked by ohia forests and lavaflows (DOWALD Exh. 4; KGS 8/27/84).

d. The areas to the west of the proposed project are designated as geothermal resource subzones. (State Exh. 2, p. 5; KMERZ GS No. 9/26/85-5).

e. The 2,000 foot buffer area between the proposed Kahauale'a Natural Area Reserve and the GRS will allow the potential impacts from noise and air emissions from any geothermal activity to be mitigated by the use of the best available technology and the distance between the two areas.

f. The development of geothermal resources in the Kilauea Middle East Rift Zone is consistent with the Hawaii State Plan which has an objective and policy of increasing energy self-sufficiency and promotion of the use of new energy resources; and has a priority action of encouraging the development of alternate energy sources (Sections 226-18(a)(2), 103(i)(1), HRS). The development of geothermal energy by the project will provide the private sector with opportunities to develop latent geothermal energy resources in those areas where the potential for finding such resources is high. State and County goals for the development of Hawaii's natural energy resources will, thus, be enhanced and furthered. (Applicant's Exh. 13, p. 1-2; County Exh. 1, p. 3; KMERZ 9/26/85-5).

g. The development of geothermal energy in the Kilauea Middle East Rift Geothermal Zone is consistent with the goals and policies of the Hawaii County Plan which encourages the development of alternate energy resources; promotes a proper balance between the development of alternate energy resources and the preservation of environmental fitness; and encourages the use of new energy sources (County Exh. 1, p. 3; KMERZ 9/26/85-5).

1.2 Compatibility With the Goals and Objectives of the Conservation District

a. Hawaii's land use law (Chapter 205, Hawaii Revised Statutes) provides that the Land Use Commission, State of Hawaii, is responsible for classifying all of the land in this State into one of four categories: urban, rural, agricultural, and conservation.

b. Section 205-5, Hawaii Revised Statutes, further provides that conservation lands shall be governed by the BLNR pursuant to Section 183-41, Hawaii Revised Statutes. Section 205-2, Hawaii Revised Statutes, further provides that:

> Conservation districts shall include areas necessary for protecting watersheds and water sources; preserving scenic and historic areas; providing park land, wilderness, and beach reserves; conserving endemic plats, fish and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openess, natural condition, or present state of use if retained, would enhance the present potential value of abutting or surrounding communities or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational

purposes; other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

c. Like federal land use law (40 USC 1411-18; 43 USC 315; 315, 869; 30 USC 181 et. seq. 30 USC 351-359. Regulations: 30 CFR-whole; 43 CFR subpart 2420; 43 CFR-whole), the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation land involve multiple uses which range from absolute preservation to regulated uses. For example, the ocean includes a range of activities from estuaries to harbors. These range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restrict context.

d. The multiple uses permitted in the Conservation land use district outlined in HRS 183-41 reflect a weighting of long term environmental values against limited categories of human needs. For example, the long term protection of the watershed must be balanced with the need to withdraw water for domestic use. Likewise, a project which requires unique location within a conservation zone and benefits thel arge public may be necessary while a project easily sited elsewhere might not be proper. For example, a hydroelectric dam which serves a larger population may be uniquely and properly located in a conservation district to take advance of a waterfall; whereas a multitude of single family homes would be inappropriate even though both are similarly intrusive. The unique balancing depends upon more specific factors developed and authorized by the Board's zoning regulations.

e. DLNR Conservation Definition:

(1) The Board's administrative rules define conservation to mean:

> A practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural ad secenic resources attendant to land . . .to ensure optimum long-term benefits for the inhabitants of the State. (DLNR 13-2-1).

(2) This definition reiterates the balance of values and multiple use character of conservation lands. (BLNR Conclusions of law 8.1.1.3. CDUA HA 3/2/82-1463).

Purpose and intent of Conservation District

> In reviewing applications, the following guidelines shall apply: . .. (4) all applications shall meet the purpose and intent of the State's conservation district. (DLNR 13-2-21(b)(4))

f. The proposed project is in the State Land Use Conservation District and in an area designated as a geothermal resource subzone which allows geothermal activities as a permitted use. (Chapter 205-5.1, HRS).

g. Section 205-5.1(a), HRS, permits geothermal resource subzones to be established within State Land Use Conservation Districts. Act 155, Session Laws of Hawaii, 1984, specifically states that geothermal development activities may be permitted within conservation land use districts.

h. The use of an area for the exploration, development and production of electrical energy from geothermal resources within a geothermal resource subzone shall be governed by the Board of Land and Natural Resources within the conservation district (Section 205-5.1(c), HRS).

i. Section 183-41, HRS, states that the BLNR should allow and encourage the highest economic use of conservation lands.

j. The nature of geothermal development activities are non-labor intensive activities and are more appropriately characterized as capital intensive. (EIS, CDUA Hearing, Appendix H, H-1; Applicant's Exh. 5, p. 2). Therefore, geothermal development activities can be allowed within the geothermal subzone by reducing the exposure of humans to the potential volcanic dangers by the strategic placement of powerplants, the erection of berms and platforms to minimize the potential volcanic hazard, the use of escape roads the careful formulation of evacuation plans in advance of potential dangers and the close coordination of the operations of the geothermal project with the Hawaii Volcanoes Observatory to facilitate the exchange of important information (Written Testimony of Gerald Niimi and Louis Capuano, BLNR Hearing, April 11, 1984).

k. The availability of proven geothermal technology such as hydrogen sulfide abatement systems which are capable of abating hydrogen sulfide emissions to 99%; noise reduction technology for well-venting (in-place and portable rock mufflers and drilling emission abatement systems; drilling rig noise reduction techniques (acoustical baffling, hospital muffers, noise reduction enclosures); strategic placement of powerplants and use of landscaping to reduce potential visual impacts; the use of reinjection programs to return geothermal fluid back to the production zone; geothermal well storm plugs and buried cellars; raised platforms and berms; will reduce the potential impacts of geothermal development within the conservation district and and within areas surrounding the proposed subzone. (DOWALD Exh. 9; KGS 8/27/84, Written Testimony of Gerald Niimi, Louis Capuano, BLNR hearing, April 11, 1983).

CONCLUSIONS OF LAW

1. That the BLNR has jurisdiction over this action pursuant to Section 205-5.1 and 205-5.2, HRS.

2. That geothermal development activities are a permitted use as set forth in Section 205-5.1 (a) which reads in relevant part "Geothermal development activities may be permitted within urban, rural, agricultural, and conservation land use districts in accordance with this chapter. Geothermal development activities means the exploration, development or production of electrical energy from geothermal resources."

3. That the granting of the CDUA:

(a) Will not have an unreasonable adverse health, environmental, or socio-economic effect on residents or sounding property;

(b) Will not unreasonably burden public agencies to provide roads and streets, sewers, water, drainage, school improvements, and police and fire protection; and

(c) That there are reasonable measures available to mitigate the unreasonable adverse effects or burdens referred to in 3(a) and 3(b) above.

4. The Applicant has proven that its proposed project is consistent with and meets the purpose and intent of the State's Conservation District, and can meet all conditions and guidelines, except condition 15 set forth in the Department of Land and Natural Resources Regulation No. 4, Section 6 (a) and (b) which read as follows:

SECTION 6.

STANDARDS: LAND USE CONDITIONS AND GUIDELINES

A. Conditions:

Any use allowed within the Conservation District after the effective date of this Regulation is subject to the following conditions:

1. The use shall be compatible with the locality and surrounding areas, and appropriate to the physical conditions and capabilities of the specific parcel(s) of lands;
2. The existing physical and environmental aspects of the subject areas, such as natural beauty and open space characteristics, shall be preserved or improved upon, whichever is applicable;
3. All buildings, structures and facilities shall harmonize with physical and environmental conditions stated in this Regulation;
4. Use of the area shall conform with the program of the appropriate Soil and Water Conservation District, or plan approved by and on file with the Department;
5. When provided and/or required, potable water supply and sanitation facilities must have the approval of

the Department of Health and the Board/Department of Water Supply;

6. When provided and/or required, boat harbors, docks and similar facilities must have the approval of the Department of Transportation;

7. The construction, alteration, moving, demolition and repair of any building or other improvement on lands within the Conservation District, shall be subject to the building codes of the respective counties in which the lands are located; provided that prior to the commencement of any construction, alteration or repair of any building or other improvement, four (4) copies each of the final location map, plans and specifications shall be submitted to the Chairman, or his authorized representative, for approval, provided however, that any alteration or repair which does not change or expand on the existing land use shall not be subject to the above;

8. Provisions for access, parking, drainage, fire protection, safety, signs, lighting and changes in the landscape must have the approval of the Chairman or his authorized representative;

9. Where any interference, nuisance, or harm may be caused, or hazard established by the use, the

applicant shall be required to take measures to minimize or eliminate such interference, nuisance, harm or hazard.

10. Obstruction of public roads, trails and pathways shall be minimized. If obstruction is unavoidable, the applicant shall provide roads, trails or pathways acceptable to the Department.

11. Except in the case of public highways, access roads shall be limited to a maximum of two lanes.

12. Overloading of off-site roadways, utilities and public facilities shall be minimized.

13. Clearing areas for construction purposes shall require prior approval by the Chairman. Ground cover of slopes over 40% shall not be removed unless specifically authorized by the Chairman.

14. Cleared areas shall be revegetated within thirty (30) days, unless otherwise provided for in a plan on file with and approved by the Department.

15. Upon approval of a particular use by the Board, any work or construction to be done on the land shall be initiated within one (1) year of the approval of such use, and, all work and construction must be completed within three (3) years of the approval of such use.

B. Guidelines

1. All applications shall be reviewed in such a manner that the objectives of the subzone(s) is given primary consideration.
2. All applications shall be reviewed such that any physical hazard, as determined by the Department shall be alleviated by the applicant when required by the Board.
3. All applications for subdivision shall address their relationship with the City and County/County General Plan.
4. All applications must meet the purpose and intent of the State's Conservation District.
5. The only condition that cannot be met by the applicant is condition 15 under which any work or construction must be completed within 3 years of the approval.
6. A deviation is granted to the Applicant under Section 6 c of Regulation No. 4 from condition 15 as the deviation is necessary because there are no practical alternatives if the Applicant wishes to build and construct its project in reasonable and prudent manner. Further, the deviation will not result in any significant adverse effects to the environment, and in fact will result in a better

planned project which will have less effect on the environment. Finally, the deviation does not conflict with the objectives of a geothermal resource subzone.

7. The Applicant has shown that the proposed project has an acceptable balance of the factors that are set forth in Section 205-5.2 (b) 1-7 which read:

(1) The area's potential for the production of geothermal energy;

(2) The prospects for the utilization of geothermal energy in the area;

(3) The geologic hazards that potential geothermal projects would encounter;

(4) Social and environmental impacts;

(5) The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

(6) The potential economic benefits to be derived from geothermal development and potential related industries; and

(7) The compatibility of geothermal development and potential related industries with the uses

permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

(8) The use proposed within the KMERZ/GRS is in conformity with the expressed subzone objectives in Section 13-184-3, as required in Section 13-2-21(B(1).

O R D E R

IT IS HEREBY ORDERED that the the Estate of James Campbell and the True/Mid-Pacific Venture shall be allowed, as a permitted use, to explore and develop the KMERZ/GRS, identified as TMK 1-2-08:07, 11-17; 1-2-10:1, 3; 1-5-01:10-13, 40-48, 52, 55, for geothermally produced electrical power subject to the following conditions:

1. Exploration and development of the KMERZ/GRS shall be limited to the production of 100 megawatts of electrical power. The maximum size of any one individual power plant shall be limited to a size of 55 MW. Initial exploration activity shall commence in Exploration and Development Area "A" as shown in Figure 5 of the Final Supplemental Environmental Impact Statement. The number of wells shall be limited to a total number of forty-three (43) exploration, production and injection wells.

The initial development phase will be limited to the production of electrical power capable of satisfying the electrical energy requirements for the Island and County of Hawaii. Exploration drilling may be conducted during this initial development stage to prove the existence and define the extent of geothermal resources capable of satisfying the 100 megawatt development capacity.

The second and subsequent development phases may be initiated within the scope of this permit, to supply power necessary for the installation of an undersea deep water cable for export of power to other islands and for any additional power requirements for the Island of Hawaii.

2. The term of this permit shall be for a period of 65 years consistent with the mining lease provisions covering the KMERZ/GRS, the granting of which and the terms thereof are under the authority of the BLNR.

3. Exploration activities shall be commenced within three years of the BLNR's approval of the Plan of Operations in accordance with Section 13-183-54(g) of the Rules on Leasing and Drilling of Geothermal Resources.

4. Applicant shall submit to the BLNR for its review and approval prior to initiating any operations including access road construction or drilling, a Plan of Operations in accordance with the detailed requirements of Section 13-183-55 of the Rules of Leasing and Drilling of Geothermal Resources. The plan shall include site

selection, planned well depth, and bottom hole location. The Plan of Operations shall also include the following:

(a) Air Quality Monitoring Program to be in compliance with the requirements of the State Department of Health's Authority to Construct Regulations as defined in Title 11, Chapter 60, Air Pollution Control, State Department of Health, including those relating to drilling operations. The program shall include monitoring for:

1. Hydrogen Sulfide
2. Sulfur Dioxide
3. Mercury
4. Radon
5. Total Suspended Particulates
6. Rain water sampling

The air quality monitoring program shall be initiated upon commencement of drilling and conducted for four (4) months to one (1) year prior to submitting an application for "Authority to Construct" a power plant. Monitoring sites for exploration and development drilling, and for power plants when plant sites are determined, will be located so as to obtain the maximum emissions from these operations. Where appropriate, U.S. EPA monitoring guidelines and protocol will be followed and standard U.S. EPA quality assurance documentation will be provided for the monitoring program. Detailed quarterly reports will be submitted so that the status of the air quality can be routinely reviewed by appropriate regulatory agencies.

(b) Meteorological Monitoring Program in conjunction with the Air Quality Monitoring Program for compliance with the State Department of Health Authority to Construct regulations including drilling operations. The program shall describe the number and locations of the meteorological stations and include provisions for the measurement of vertical air temperatures and rainfall.

(c) Biological Survey Plan for the assessment of the biota prior to clearing operations of specific sites for project facilities including roads, drilling and power plant sites. Provisions shall be included to monitor the impacts of project activities on the environment in general and in particular for the introduction of exotics into any cleared areas. The plan will include contingencies for the avoidance of any candidate endangered or threatened plant species or the nests of the Hawaiian Hawk.

(d) An archaeological reconnaisance survey plan for clearing operations for specific sites for project facilities including roads, drilling and powerplant sites to include plans for the avoidance of any sites that are determined to be worthy of preservation or removal. More specifically:

(1) A full archaeological reconnaisance survey shall be conducted for any area selected to be cleared for project operations, prior to the initiation of clearing operations.

(2) The full reconnaisance survey shall identify and evaluate sites and features of potential archaeological significance present within the areas to be cleared.

(3) The full reconnaisance survey shall be conducted in accordance with the standards for reconnaisance level survey recommended by the Society for Hawaiian Archaeology (SHA).

(4) The appropriate areas to be surveyed include the proposed access corridors, drill sites, powerplant sites and any other areas to be impacted by construction activities. These areas will be clearly marked on-the-ground prior to any archaeological field work.

(5) The survey areas will also include sufficient buffer zones -- ranging from two to five times larger than the actual extent of the access road corridors, drill sites, powerplant sites, and any other development areas -- to insure that any archaeological resources in the immediate vicinity, but not actually within a specific area to be impacted will not be inadvertently damaged by construction activities. The buffer area should also insure

that the full context of archaeological remains within the specific impact areas will be determined (e.g., the full significance of a seemingly isolated structure cannot be accurately determined if it is part of a larger, but unidentified, complex of structures).

(6) An archaeological research design to guide all future archaeological work within the project area will be formulated. A research design will be a plan for conducting an archaeological investigation.

(e) Administrative and emergency plans relative to fire, volcanic activity, earthquakes, well bore ruptures and blowouts and any other emergency situations which may threaten the health, safety and welfare of the employees and other persons in the vicinity of the proposed project. The plans will also include operational requirements relating to parking and access.

(f) Disposal procedures for any toxic materials or sump contents and other waste materials as may be necessary for disposal in sites as approved by the State Department of Health.

(g) Procedures for any necessary unabated venting of the wells to include the times and circumstances when such venting will be conducted, including provisions for notification of the public.

(h) Procedures for shielding lights on the drilling rig during operations.

(i) Noise abatement methods for quieting drilling equipment including equipment modifications to assure compliance with noise guidelines.

(1) Applicant will conduct on-site monitoring of noises from drilling operations at specific downwind distances from the drilling rig to allow an accurate assessment of the effectiveness of the noise abatement technology being employed on the drilling rig, and whether further noise abatement adjustments are required. Periodic measurements shall be conducted with mobile monitoring equipment at the closest residential areas to the project activities to further validate the effectiveness of the abatement measures. Such mobile monitoring will be conducted in coordination with residents in the closest residential areas during times when meteorological conditions are most conducive to sound propagation to those areas.

(2) Until such time as noise regulations are adopted by the State or County, the Applicant will conform its geothermal activities to the County of Hawaii Planning Department Noise Guidelines as related to geothermal development. The guidelines provide:

(a) A general noise level of 55 dBA during daytime and 45 dBA at night shall not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

(b) The allowable noise levels may be exceeded by a maximum of 10 dBA; however, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period;

(c) The noise level guidelines shall be applied at the existing residential receptors which may be impacted by the geothermal operation; and

(d) Sound level measurements shall be conducted using standard procedures with sound level meters using the "A" weighting and "slow" meter response unless otherwise stated.

(k) A procedure for the submittal of reports and records relating to:

1. Well test data;

2. Exploration results;

3. Drilling Logs;

4. Production and payments from the operations;

5. Log of any public complaints concerning project operations and activities;

6. Periodic survey and monitoring reports relating to air quality meteorology, archaeological reconnaisance, and flora and fauna.

(l) Procedure for the processing of public complaints concerning project activities including the designation of a Big Island resident to receive potential complaints and the designation of an individual who is available in the State and who has the authority to act on behalf of the Applicant for the purposes of supplying information and responses to the representatives of state and county governmental agencies on relevant matters.

(m) A metes and bounds description of any well site, powerplant site, and access or connecting road rights-of-way including the adequate marking of these areas.

(n) A plan for the restoration of drilling, powerplant and road sites including measures for the revegetation of any cleared areas deemed appropriate by the BLNR.

(o) Mitigation measures to reduce visual impacts on the areas surrounding the project facilities shall include: orientation of buildings, when feasible, with the narrow dimension towards any view corridor from which large numbers of the public would be able to observe the facility, paint to blend with the background for the facility, and the use of nonreflective, light absorbent material and textures.

5. Until air quality regulations concerning geothermal activities are promulgated by the State of Hawaii, the Applicant shall comply with the proposed State Department of Health Air Quality Regulations concerning ambient air quality and geothermal emission rates for drilling and power plant operations.

6. Best Available Control Technology (BACT) shall be used during all phases of the project to limit or reduce project noise, and gaseous and fluid emissions to comply with applicable standards. BACT shall mean that which will best achieve the degree of control required, taking into account what is known to be practical in terms of energy required to operate the system, the environmental conditions, and the economic considerations associated with the currently available technology. BACT for any specific application will be determined by the Federal, State or County agency having specific enforcement or monitoring responsibility in the area to be controlled.

7. The Chairperson of the BLNR will periodically, at his discretion, review the implementation of the proposed project with respect to (a) adherence to the Plan of Operations for the project within the terms and conditions

imposed herein and (b) the results of the environmental monitoring program to be implemented.

8. Use of the area shall conform with the program of the appropriate soil and water conservation district or plan approved by and on file with the State Department of Land and Natural Resources.

9. When provided or required, potable water supply and sanitation facilities shall have the approval of the State Department of Health and the board/department of water supply.

10. The construction, alteration, moving, demolition and repair of any building or other improvement on lands within the conservation district shall be subject to the building codes of the respective counties in which the lands are located; provided that prior to the commencement of any construction, alteration, or repair of any building or other improvement, copies of the final location map, plans, and specifications shall be submitted to the chairperson or an authorized representative, for approval; provided, further that any alteration or repair which does not change or expand on the existing land use shall not be subject to the above.

11. Obstruction of public roads, trails, and pathways shall be minimized. If obstruction is unavoidable,

the Applicant shall provide roads, trails, or pathways acceptable to the Department of Land and Natural Resources.

12. Except in the case of public highways, access roads shall be limited to a maximum of two lanes.

13. Overloading of off-site roadways, utilities, and public facilities shall be minimized.

14. Notwithstanding any of the foregoing, the Applicant or its authorized representative shall be responsible for complying with all applicable Federal, State and County of Hawaii statutes, ordinances, rules and regulation governing this permit.

ALTERNATIVE ORDER

In the event the BLNR determines that development to a level of 100 MW must be accomplished on an incremental basis, the following alternative Order is proposed:

IT IS HEREBY ORDERED that the Estate of James Campbell and the True/Mid-Pacific Geothermal Venture shall be allowed, as a permitted use, to explore and develop the KMERZ/GRS, identified as TMK 1-2-08:07, 11-17; 1-2-10:1, 3; 1-5-01:10-13, 40-48, 52, 55, subject to the following conditions:

1. Exploration of the KMERZ/GRS shall be conducted to prove the existence and define the extent of a

geothermal resource capable of satisfying 100 MW of development capacity.

2. Applicant shall be immediately permitted to develop up to 25 MW of electrical power for purposes of satisfying the electrical energy requirements for the Island and County of Hawaii.

3. Development by the Applicant of geothermal energy in excess of the initial 25 MW shall be permitted by the BLNR only upon a reasonable showing by the Applicant that:

(a) It has complied with all of the terms and conditions in this Order;

(b) A need can be shown for the development of additional geothermal energy; and

(c) The development of additional geothermal facilities can continue to meet and be in compliance with applicable health and safety requirements of applicable, Federal, State and County statutes.

4. All other conditions previously referred to above numbered 2 through 13.

Done at Honolulu, Hawaii, this _______ day of ____________________, 1986.

BOARD OF LAND AND NATURAL
RESOURCES, STATE OF HAWAII

By ______________________________
SUSUMU ONO, Chairman

By ______________________________
ROLAND H. HIGASHI

By ______________________________
MOSES W. K. KEALOHA

By ______________________________
J. DOUGLAS ING

By ______________________________
LEONARD H. ZALOPANY

By ______________________________
JOHN Y. ARISUMI

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing document was duly hand delivered and/or mailed to the persons named below at their last known address on MAR 21 1986.

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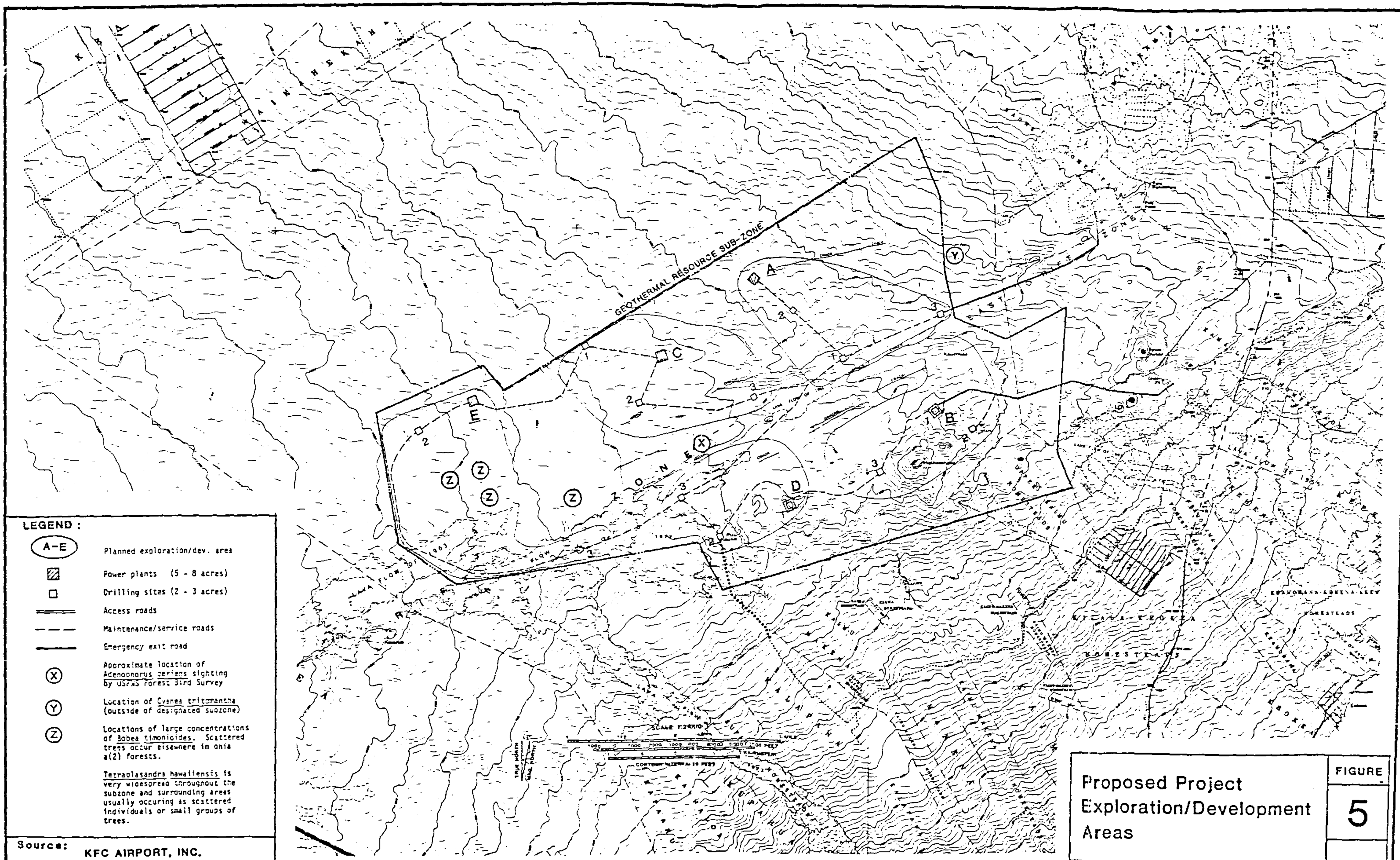

Proposed Project Exploration/Development Areas

FIGURE 5

APPLICANT'S EXHIBIT 1(a)

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone	)	G.S. NO. 9/26/85-5 Findings of Fact Conclusion of Law Decision and Order

Honolulu, Hawaii

~~March , 1985~~
April 8 1986

CONTENTS

ABBREVIATIONS

BLNR	Board of Land and Natural Resources
Board	Board of Land and Natural Resources
CDUA	Conservation District Use Application
DLNR	Department of Land and Natural Resources
DOH	Department of Health
DOWALD	Division of Water and Land Development
dB	Decibels
EPA	Environmental Protection Agency
GRS	Geothermal Resource Subzone
HAAQS	Hawaii Ambient Air Quality Standards
HELCO	Hawaii Electric Light Company
Ldn	Day-night noise levels
SLUC	State Land Use Commission
MW	Megawatts of Electrical Power
NAR	Natural Area Reserve
NPS	National Park Service
VCA	Volcano Community Association

BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Designation of the Kilauea Middle East Rift, Island of Hawaii, as a Geothermal Resource Subzone	)))))	G.S. No. 9/26/85-S Findings of Fact Conclusions of Law Decision and Order

I. INTRODUCTION

This contested case hearing dealt with the proposed designation of the Kilauea Middle East Rift zone as a geothermal resource subzone (hereinafter, "GRS").

At the request of various individuals in the vicinity of the Kilauea Middle East Rift, who would be affected by the designation of the GRS, the Board of Land and Natural Resources (hereinafter, "BLNR") conducted a three-day contested case hearing pursuant to HRS Chapter 91 and its Administrative Rules on November 13, 14, and 15, 1985, at the State Office Building, Conference Room and the County of Hawaii Council Chambers in Hilo, island of Hawaii, Hawaii. Transcripts of the hearing are on file with the Department of Land and Natural Resources in Honolulu, Hawaii.

The following Findings of Fact, Conclusions of Law, and Decision and Order ~~is~~ are issued pursuant to that hearing.

The Background, Chronology, and Legal Framework define the process leading up to the contested case hearing. The evidence presented in the Board's own Findings of Fact focus on the central issues relevant to the factors set forth in Act 296, SLH 1983, and Act 151, SLH 1984.

The rulings on the parties' proposed Findings of Fact and the Conclusions of Law represent the Board's considered and collective judgment on the designation of the Kilauea Middle East Rift as a GRS.

II. BACKGROUND

Location. The Kilauea Middle East Rift GRS as originally proposed, ~~is~~ was located between the Kamaili GRS on the southeast and the

Kahaualea section on the northwest. The originally proposed GRS encompasses ~~a total of~~ approximately 11,745 acres ~~which~~ includes the following Tax Map Keys:

TMK	Area (acre)	SLUC Designation	Owner
1-2-08:8	211	Agriculture	State
1-2-08:11	22	"	Private
1-2-08:12	17	"	"
1-2-08:13	73	"	State
1-2-08:14	90	"	"
1-2-08:15	80	"	Private
1-2-08:16	50	"	"
1-2-08:17	55	"	"
1-2-10:1	440	"	State
1-2-10:3	10,413	Conservation	"
1-5-01:10	72	Agriculture	Private
1-5-01:11	75	"	"
1-5-01:12	19	"	"
1-5-01:13	17	"	"
1-5-01:40	38	"	"
1-5-01:41	5	"	"
1-5-01:42	5	"	"
1-5-01:43	5	"	"
1-5-01:44	5	"	"
1-5-01:45	5	"	"
1-5-01:46	5	"	"
1-5-01:47	5	"	"
1-5-01:48	22	"	"
1-5-01:52	5	"	"
1-5-01:55	11	"	"
Total	11,745		

<u>Description of the GRS</u>. The Kilauea Middle East Rift GRS is located ~~midway~~ along the Kilauea East Rift Zone in an area which can be characterized as an active volcanic rift.

The Kilauea Middle East Rift Zone contains ~~a~~ portions of the Puna Forest Reserve~~, a part of which is designated as a~~ Natural Area Reserve, consisting of Ohi'a rainforest, intermixed with lava flows. The Ohia rainforest exhibits a vegetation succession ranging from newly emerged ferns on fresh lava flows to mature forests dominated by Ohia lehua trees. In higher wetter areas, Ohia lehua and hapuu usually occur together; in drier areas, ohia grows with uluhe.

The area is relatively undisturbed, but does contain some introduced plants.

Surrounding Land Uses and Zoning. The Kahaualea area to the northwest of the proposed GRS is ~~described as~~ relatively undisturbed ohia forest with open areas devastated by lava flows along the rift. ~~The GRS is separated from the Kahaualea parcel by a 2000-foot buffer area.~~

The ~~major portion of the~~ GRS ~~is contained~~ lies within the Wao Kele 'O Puna Natural Area Reserve (NAR) and is bounded on the north by the Puna Forest Reserve, Kaohe Homesteads on the northeast, the Kamaili GRS on the east, the Upper Kaimu Homesteads on the southeast, with the remaining NAR area and Kahaualea lands on the south and west, respectively.

The GRS and Subsequent Permit Process. Designation of a GRS is a land use zoning action ~~intended only to~~ which defines an area on a map ~~in~~ which geothermal ~~development~~ activities may be ~~undertaken.~~ conducted. It is the ~~initial step in a series of subsequent steps fulfilling other~~ prerequisite to any application for state ~~and~~ or county ~~zoning and~~ permit ~~requirements.~~ for geothermal exploration and development.

Events Leading Up to the Contested Case Hearing. On March 2, 1982, the Estate of James Campbell filed a Conservation District Use Application (CDUA) with the Department of Land and Natural Resources to develop geothermal resources at Kahaualea, Hawaii. This CDUA No. HA-3/2/82-1463 was processed and a draft Environmental Impact Statement prepared. ~~By~~ On May 20, 1982 a petition for a contested case hearing on the CDUA had been filed~~, and~~. A hearing was granted. The contested case hearing was convened on October 5, 1982, and continued on October 25 through 29, 1982, November 15 through 19, 1982, and December 7 through 10, 1982.

The BLNR in its Findings of Fact, Conclusions of Law, and Decision and Order dated February 25, 1983, granted the Estate of James Campbell limited exploration rights within a designated area of 800 acres located at Kahaualea.

Subsequent to the BLNR's February 28, 1983 Decision and Order, the Hawaii State Legislature passed Act 296, SLH 1983, delegating to the BLNR the responsibility of designating geothermal resource subzones throughout the State of Hawaii by selecting those areas that best demonstrate an acceptable balance among seven ~~the~~ criteria ~~set forth in the Act.~~ new codified in HRS 205-5.2

Pursuant to Act 296, SLH 1983, the Chairperson of the BLNR assigned the Division of Water and Land Development (DOWALD), of the Department of Land and Natural Resources (DLNR) the task of assessing and recommending geothermal resource subzones . DOWALD began work on the assessment of potential geothermal resource subzones on June 14, 1983, when Act 296, SLH 1983 was signed into law.

In 1984, the Legislature enacted Act 151. This act gave first priority to the assessment of the Kahaualea area as a potential geothermal resource subzone and required the BLNR to act on the designation of the Kahaualea area by December 31, 1984. DOWALD assessed the Kahaualea area and proposed a 5300-acre area for designation as a GRS.

Public information meetings and public hearings were held as part of the subzone designation process. At the public hearing held on September 12, 1984 in Hilo, Hawaii, requests for a contested case hearing on the proposed Kahaualea GRS, were made to the BLNR and ~~was~~ subsequently granted. The BLNR conducted the contested case hearing on December 12-20, 1984 in Hilo, Hawaii and issued its Decision and Order on December 28, 1984.

In the Decision and Order of December 28, 1984, the BLNR designated the 800-acre area described in its February 25, 1983 Decision and Order as a geothermal resource subzone subject to the following conditions:

(1) Cessation of volcanic activity in, around and near the area permitted by the Board's February 25, 1983 Decision and Order.

(2) No new geothermal development activity associated with the permitted area shall be considered until after it has been determined that the geologically hazardous and eruptive activity has ceased.

In the 1984 Decision and Order, the Board also formally requested the Estate of James Campbell to investigate and consider a land exchange involving State-owned lands in the Kilauea Middle East Rift Zone and Campbell Estate's lands at Kahaualea. The Board stated that should the land exchange be consummated, then the 800 acre GRS designated by the Decision and Order shall cease to exist and have no force or effect in law.

The BLNR further resolved to consider the Kilauea Middle East Rift Zone for designation as a GRS on the basis of information presented at the contested case hearing, indicating that the Kahaualea property owned by Campbell Estate contained better quality native habitat than the area identified as the Wao Kele 'O Puna Natural Area Reserve.

The Board then directed the Division of Water and Land Development to undertake and conduct an assessment of the Kilauea Middle East Rift Zone in and adjacent to the Wao Kele 'O Puna Natural Area Reserve beginning on the western boundary of the existing Kamaili GRS. This area had not previously been evaluated due to its classification as a Natural Area Reserve.

~~It should be noted that~~ Under State law Natural area reserves~~, under the law~~, must be state-owned, ~~and, as such,~~ accordingly the privately owned Kahaualea lands had not been previously considered for proclamation as a natural area reserve.

The 1984 Decision and Order further state~~s~~d that if (a) the assessment of the Kilauea Middle East Rift Zone does not result in a designation as a geothermal resource subzone, or (b) a land exchange between the State of Hawaii and the Estate of James Campbell is not consummated, then the remainder of the 5300 acre Kahaualea area originally proposed by DOWALD for designation as a GRS, shall be designated as a GRS.

In this same Decision and Order, the Board also urged the federal government and the National Park Service (NPS) to seek acquisition of Tract 22 (described in the Volcanoes National Park Master Plan), which the State will not itself seek, but which is desired by the NPS for addition to the Volcanoes National Park.

Finally, the Decision provided that "(i)f the State of Hawaii and Campbell Estate should later ~~x~~ consumate a land exchange involving lands at Kahauale'a for State or other lands upon which ~~x~~ geothermal activities may take place, then the geothermal subzone designation in this Decision and Order shall cease to exist and ~~x~~ shall have no force or effect in law, ..." ~~assessment utilized~~ the same criteria set forth in Act 296, SLH 1983, ~~that was used in assessing all other proposed and designated~~ geothermal ~~resource subzones.~~.

The assessment of the Kilauea Middle East Rift Zone is ~~documented~~ set forth in the DOWALD Circular C-114 (State Ex. 2, G.S. No. 9/26/85-5) and in the proposal to designate the area as a GRS (State Ex. 1, G.S. No. 9/26/85-5).

The BLNR held a public hearing on the proposed designation of the Kilauea Middle East Rift as a geothermal resource subzone on September 26, 1985, and at that time, a request for a contested case hearing was made to the BLNR.

On October 16, 1985 the BLNR announced that a contested case hearing would be held on the proposed GRS designation on November 13, 1985, in Hilo, Hawaii. On November 13, 14, and 15, 1985, the BLNR conducted a contested case hearing on the proposed designation of 11,745 acres in the Kilauea Middle East Rift zone as a geothermal resource subzone.

III. CHRONOLOGY

The following is a brief summary of events ~~leading up to~~ the ~~November 13, 1985, contested case hearing, proceeding~~ from the initial

Conservation District Use application for the Kahaualea Geothermal Project ~~to~~ through legislative actions, ~~and the subsequent subzone~~ designation of Con subzones and / [illegible] ~~process and~~ the designation of the Kilauea Middle East Rift as a GRS. It is not intended to be an all inclusive account, but will serve to document the sequence of significant events relating to this case.

3/2/82	A Conservation District Use Application was filed with the Department of Land and Natural Resources, Planning Office for geothermal development of the Campbell Estate Kahaualea property (CDUA No. HA-3/2/82-1463).
5/20/82	A public hearing on the CDUA was held at the Hilo High School Auditorium. Requests for a contested case hearing on the CDUA were received by the BLNR.
7/30/82	Department of Land and Natural Resources accepted the Final Revised Environmental Impact Statement for the Kahaualea Geothermal Project.
10/5/82) 10/25-29/82) 11/15-19/82) 12/7-11/82) 1/13/82)	Contested Case Hearing held on the dates indicated.
2/4/83	BLNR served its proposed Findings of Fact, Conclusions of Law and Decision and Order on the parties.
2/10/83	The BLNR heard final oral arguments by the parties.
2/25/83	BLNR rendered Decision and Order on Conservation District Use Application (CDUA) File No. HA-3/2/82-1463 for Kahaualea Geothermal Project filed by the Estate of James Campbell. The BLNR granted Campbell Estate a permit to conduct baseline and exploratory activities for measuring, monitoring and observing potential geothermal resources in a specified area. The permit outlined 43 general and specific conditions providing guidelines and safeguards for an orderly exploratory program. The Decision and Order set time periods for eleven conditions where certain actions were required; specifically, a one-year ambient air quality survey, submittal of an environmental monitoring plan, meteorological monitoring, and development and submission of an exploration plan.
1983 Legislative Session	The Hawaii State Legislature passed Act 296, SLH 1983, delegating to the Board of Land and Natural Resources the responsibility for designating geothermal

	resource subzones by selecting areas that can best demonstrate an acceptable balance among the factors or criteria set forth in the Act.
6/14/83	Act 296, SLH 1983 signed into law. The Chairperson of the Board assigned the task of recommending geothermal resource subzones to the Department of Land and Natural Resources' Division of Water and Land Development (DOWALD).
3/12/84	Supplemental CDUA Hearing held on volcanic hazards.
5/22/84	In accordance with Chapter 91 and 205, Hawaii Revised Statutes, and Act 296, SLH 1983, public hearings on the "Proposed Rules for the Designation and Regulation of Geothermal Resource Subzones" were held on all islands by the Department of Land and Natural Resources.
7/13/84 8/24/84 (amend.)	The DLNR Administrative Rule Title 13, Chapter 184, describing the procedure for initiating the designation of subzones, establishing criteria for designation, providing for the modification and withdrawal of existing subzones, and providing for the regulation of geothermal resource subzones was formally adopted by the BLNR.
1984 Legislative Session	The Hawaii State Legislature adopted Act 151, SLH 1984, clarifying the rights of existing lessees holding geothermal mining leases issued by the State or geothermal developers holding exploratory and/or development permits from either State or County governments. Act 151 also clarifies the respective roles of the State and County governments in controlling geothermal development within geothermal resource subzones. Act 151 also assigned first priority to the assessment of the Kahaualea area as a potential geothermal resource subzone by requiring the BLNR to act on the proposed designation of the Kahaualea area by December 31, 1984.
5/25/84	Act 151, SLH 1984, signed into law.
May-July 1984	A series of public information meetings on the subzone designation process were held by the Division of Water and Land Development on the following days at the locations indicated.

May 8, 1984	Hilo, Hawaii
May 9, 1984	Kahului, Maui
May 29, 1984	Hilo, Hawaii
May 30, 1984	Kahului, Maui

	July 10, 1984	Puna Community Council, Hawaii
	July 27, 1984	Ulupalakua, Kanaio, Maui
	July 30, 1984	Pahoa Community Council, Hawaii

9/10-12/84 A series of public hearings on the proposed designation of geothermal resource subzones were held on the following dates at the locations indicated.

September 10, 1984	Kula Elementary School, Maui
September 11, 1984	Pahoa Elementary School, Hawaii
September 12, 1984	Campus Center, UH-Hilo, Hawaii
September 12, 1984	Volcanoes National Park, Hawaii

9/12/84 A contested case hearing was requested at the Hilo public hearing on the designation of the Kahaualea area as a geothermal resource subzone.

11/16/84 The BLNR designated the Kilauea Lower East Rift (Kapoho and Kamaili sections) and the Haleakala Southwest Rift as Geothermal Resource Subzones.

12/12-20/84 A contested case hearing on the designation of Kahaualea as a GRS was held at the State Office Building in Hilo.

12/24/84 All parties to the contested case hearing submitted their proposed findings of fact and conclusions of law to the BLNR.

12/28/84 The BLNR rendered a preliminary Decision and Order in the matter of the proposed designation of the Kilauea Upper East Rift (Kahaualea) Island of Hawaii, as a GRS.

2/12/85 The Estate of James Campbell received approval from the Chairperson of BLNR for right of entry into the Puna Forest Reserve and Wao Kele 'O Puna Natural Area Reserve to conduct a preliminary ground reconnaissance of the area.

2/18/85 Field survey undertaken to relocate air quality monitoring instruments as part of the assessment of the Kilauea Middle East Rift Zone in and adjacent to the Natural Area Reserve.

3/13-14/85 Public information meetings held at Keaau and Pahala to report on the most likely location of geothermal resources in the Kilauea Middle East and Southwest Rift Zones.

5/15-16/85 Second set of public information meetings held at Pahoa and Pahala and focused on the identification of impact issues in the two areas being considered for subzone designation. Public review and comment was solicited at each meeting held.

9/26/85	Public hearings were held on the designation of the Kilauea Middle East Rift Zone and the Kilauea Southwest Rift Zone as a GRS.
9/26/85	A contested case hearing on the proposed GRS designation of the Kilauea Middle East Rift Zone was requested at the public hearing held in Pahoa, Hawaii.
10/25/86	The BLNR approved the amendment to the December 28, 1984, Decision and Order concerning the proposed GRS at Kahaualea, Hawaii. In the original Decision and Order, the Board opted to exclude "Tract 22" (containing 5795 acres) from the lands being proposed for exchange. However, pursuant to discussions between the State of Hawaii, Campbell Estate, and the National Park Service, the BLNR moved to amend the Decision and Order to include the parcel of land known as "Tract 22" as part of the lands proposed for exchange between the Estate of James Campbell and the State of Hawaii.
10/25/85	The BLNR formally approved the exchange of Campbell Estates Kahaualea land, identified by Tax Map Keys 1-1-01:portion of 01 and 1-2-08:01 at Kahaualea, Puna, Hawaii consisting of 25,807.055 acres for State land in Puna, Hawaii, identified by Tax Map Keys 1-2-10:01, 02, 03 consisting of 27,785.891 acres. Also, the designation of the Kahaualea area as a Natural Area Reserve is planned to take effect subject to the consummation of the land exchange and legislative approval.
10/25/85	The BLNR approved the cancellation of the Governor's Executive Order No. 3103 covering the land area described as the Wao Kele 'O Puna Natural Area Reserve identified by TMK: 1-2-10:03 pursuant to the Decision and Order of December 28, 1984; cancellation is to take effect upon the consummation of land exchange subject to legislative approval.
11/1/85	First prehearing conference held at the office of the Division of Water and Land Development, Honolulu, Hawaii.
11/7/85	Second prehearing conference held at the same location.
11/13/85	Palikapu Dedman and Emmet Aluli granted intervenor status by the BLNR.

11/13-15/85	The contested case hearing on the proposed designation of the Kilauea Middle East Rift as a GRS was held in Hilo, Hawaii.
12/4/85	Seven of the eight parties to the hearing submitted their proposed findings of fact and conclusions of law to the BLNR.
12/20/85	The BLNR issued its Decision and Order on the designation of the Kilauea Middle East Rift GRS with the Findings of Fact and Conclusions of Law to be issued spearately.

IV. LEGAL FRAMEWORK: Chapter 205, HRS.

V. FINDINGS OF FACT

This section discusses the Board's general findings regarding the factors listed in Act 296, SLH 1983, which were assessed in designating the Kilauea Middle East Rift GRS.

These factors are:

a. The area's potential for the production of geothermal energy;

b. The prospects for the utilization of geothermal energy in the area;

c. The geologic hazards that potential geothermal projects would encounter;

d. Social and environmental impacts;

e. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

f. The potential economic benefits to be derived from geothermal development and potential related industries; and

g. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

h. In addition, the board considered, where applicable, objectives, policies and guidelines set forth in part I of chapter 205A, the Hawaii Coastal Zone Management Act, and the provisions of chapter 226, the Hawaii State Planning Act. (§205-5.2(b), HRS; Chapter 13-184, Hawaii Administrative Rules of the DLNR; State Ex. 14, p. 3)

A. <u>Area's Potential for Production of Geothermal Energy</u>

1. Production of electrical energy from a geothermal resource utilizing present day technology requires that the geothermal resource have a temperature greater than 125°C at a depth of less than 3 km and a permeable geologic formation that permits adequate recharge of water into the geothermal reservoir.

2. The presence of a geothermal resource with potential for production of electrical energy can be determined by examining specific geological, geophysical and geochemical data.

3. A Geothermal Resources Technical Committee consisting of experts in geothermal resource research in Hawaii completed a statewide geothermal resource assessment, as mandated by Act 296, SLH 1983.

4. The statewide geothermal resource assessment was based on a qualitative interpretation of regional surveys and available exploratory drilling data going back 15 to 20 years.

5. The committee's assessment of regional data included the following geological, geophysical and geochemical data:

a. <u>Ground water temperature data</u>. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

b. <u>Geologic age</u>. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

c. <u>Geochemistry</u>. Ground water having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered ground water are anomalously high silica (SiO_2), chloride (Cl) and magnesium (Mg) concentrations. In addition, the evidence of above normal concentrations of trace and volatile elements such as mercury (Hg) and radon (Rn) may indicate leakage of geothermal fluids into nearby rock structures.

d. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of circulating ground water. Therefore rocks saturated with warm saline ground water have lower resistivities than rocks saturated with colder ground water.

e. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above-ambient ground temperatures.

f. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

g. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered, have substantially different magnetic properties than normal rock strata.

h. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

i. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

j. Self-potential. Self-potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea East Rift.

6. No single geothermal exploration technique, except for exploratory drilling is capable of positively identifying a subsurface geothermal system.

7. A high temperature geothermal resource area is defined as an area having an assessed probability of at least a 25% chance of finding a geothermal resource with a temperature greater than 125°C at a depth of less than 3 km.

8. The Geothermal Resources Technical Committee concluded that there are seven high temperature geothermal resource areas in the State of Hawaii:

Area	Percent Probability
Haleakala S.W. Rift Zone, Maui	25% or less
Haleakala East Rift Zone, Maui	25% or less
Hualalai, Hawaii	35% or less
Mauna Loa S.W. Rift Zone, Hawaii	35% or less
Mauna Loa N.E. Rift Zone, Hawaii	35% or less
Kilauea S.W. Rift Zone, Hawaii	Greater than 90%
Kilauea East Rift Zone, Hawaii	Greater than 90%

9. Two areas were assessed to have a probability of greater than 90% chance of finding a high temperature resource. They are the Kilauea Southwest Rift Zone and the Kilauea East Rift Zone on the island of Hawaii.

10. Currently available studies demonstrate positive geochemical and geophysical data, including recent eruptive and intrusive activity, indicating that there is a greater than 90% chance of finding a high temperature geothermal resource along the entire length of the Kilauea East Rift Zone.

11. These high temperature resource area were mapped by the Geothermal Resource Technical Committee and are defined by boundaries which indicate a greater than 90% chance of finding a high temperature resource. Areas having a 25% to 90% probability were also defined by boundaries indicating 25% chance of finding a high temperature resource, as shown on State Exhibit 4 (G.S. No. 9/26/85-S).

12. The Kilauea Middle East Rift GRS is located along the Kilauea East Rift Zone and includes within its boundaries the 90% probability

area as well as a portion of an area having less than 90% probability to the north as shown on State Exhibit 4.

13. The Kilauea Middle East Rift GRS is adjacent to a portion of Kilauea east rift zone now designated as the Kamaili GRS and the upper east rift area known as Kahaualea.

14. Commercially feasible quantities of steam have been confirmed by deep exploratory drilling in the lower east rift.

15. The presence of a permeable zone that permits an adequate recharge of water to the geothermal reservoir in the Kilauea Middle East Rift GRS can be confirmed only by exploratory drilling and flow testing of deep exploratory wells. Exploratory geothermal well drilling can only be carried out within a designated GRS.

16. The Board finds that the Kilauea Middle East Rift Zone, as proposed for GRS designation, possesses a high potential for a developable geothermal resource, but that this potential must be confirmed by exploratory drilling and flow testing.

B. Prospects for Utilization of Geothermal Energy in the Area

17. The Hawaii State Energy Plan sets forth the objective to explore and develop alternate energy resources to accelerate the transition from fossil fuel to an indigenous renewable energy economy.

18. Interest in development of geothermal resources was stimulated by a request for proposal (RFP) issued in 1980 by HELCO. The RFP was for geothermally generated electrical power to meet future demands in 1988.

19. Based upon geothermal permit applications to DLNR and the County of Hawaii, in addition to continued developer interest, the potential use and development of this resource is clearly evident.

20. The designation of the Kilauea Middle East Rift GRS is in accordance with the goals and objectives of the County of Hawaii. The energy element of the County General Plan sets forth the goal to become energy self-sufficient and to establish the development and use of the island's natural energy resources.

21. The County's policy provides for the development and research of alternate energy resources. This provision is based on the County's dependence on imported oil, the vulnerability to changes in the global oil market and the island's potential natural energy resources.

22. Federal PURPA regulations require public utilities to purchase electrical power produced from alternate sources such as geothermal energy.

23.HELCO has stated their goal to utilize geothermal energy as part of the island's source of electricty and that it holds the most promise for firm base load power. Sixty percent of the island's current electrical needs are derived from fossil fuel and HELCO is looking towards meeting these demands through alternate energy sources and reducing their dependence on oil-fired electrical generation.

24. Based on HELCO's 5-year forecast and the possible closing of the Puna Sugar Company, HELCO is planning for alternate sources of electrical power generation. In order to meet these future demands, HELCO is considering geothermal energy as a possible resource.

25. The current anticipated need for electricty by 1988 is estimated at 8.25 MW. This additional demand could be satisfied by the installation of 3 new diesel-fired generators. However, a minimum 13 MW unit would be required since that is the smallest unit that could be economically installed.

26. If a firm commitment was made to install a 13 MW geothermal plant by late 1988, then HELCO could defer the installation of a diesel generating unit until 1991.

27. HELCO has stated that if they are unable to purchase electricty from the sugar companies in 1991, they would conceivably need another 13 MW of power and possibly another 14 MW in 1993 if the HCPC contract is not renewed. Therefore, a total of 40 MW could be required by 1993.

28. There are no planned schedules to retire any of HELCO's oil-fired plants; however, HELCO has stated that should a firm alternate power source be developed, HELCO would consider retiring their older geenrators by replacing them with geothermal powered electrical units.

29. If HELCO were to replace all fossil fuel generators with alternate energy resources in order for the County of Hawaii to become energy self-sufficient by 1990, the island of Hawaii would require in excess of 100 MW of electrical power by that date.

30. HELCO is planning to construct a new transmission line to transport electricity from east Hawaii to west Hawaii. Should development in west Hawaii require addtional electricity, it is HELCO's plan to transport electricity from east Hawaii, where potential geothermal resources are located.

31. HELCO has stated that the energy needs of the island of Hawaii could be fulfilled through a combination of diesel, wind, hydro, and biomass generation, dependent however, upon the actual load growth of the island and the reliability and economics of the type of electrical generation that is used.

32. The island of Oahu, lacking sufficient alternate energy resources, accounts for 80% of the State's total consumption of electricity.

33. ~~Therefore, a~~ The feasibility of deep-water electrical transmission cable is studied being developed to connect the islands of Hawaii and Oahu. This cable, if commercially feasible, would increase the demand for geothermally generated electricty.

34. The design and construction of the prototype cable ~~is~~ will be tested ~~projected for~~ in 1987 when a 30,000-foot length of test cable will be laid in the ocean channel between the Big Island and Maui.

35. The exploration and development of alternate energy such as geothermal resources should be coordinated with the development and installation of the undersea cable. In order to meet the future electrical demands created by the potential installation of the inter-island cable, geothermal resource confirmation and development is required.

36. The Board finds that there are definite prospects for utilization of geothermal energy in the Kilauea Middle East Rift GRS.

C. Geologic Hazards

37. The same volcanic activity that provides the source of geothermal energy also creates potential geologic hazards to development. These potential hazards include lava flows, pyroclastic fallout, ground cracks, subsidence, earthquakes, and tsunami.

Lava Flows

38. Geology is not an exact science. The time and location of eruptions cannot be predicted with any degree of certainty.

39. Past geologic episodes can give some idea of future events; however, it is difficult or impossible to accurately predict the future occurrence of geologic hazards with any degree of scientific certainty.

40. The Kilauea Upper East Rift Zone is more subject to inundation by lava flowx than is the lower east rift zone. Puu O'o is presently providing the least resistive path to the surface for intrusive magma along the Kilauea East Rift Zone. Although impossible to predict, it is unlikely that eruptions will occur downrift while the Puu O'o eruptions continue.

41. Lava being fluid in nature, tends to flow directly down the steepest available slope and follows the path of least resistance.

42. The southern portion of the rift is therefore more prone to be covered by lava flows than the northern portion. The elevation of mildly sloping ridges north of the rift zone axis offer protection from lava hazards.

43. The entire Kilauea East Rift Zone is potentially vulnerable to future lava flow inundation. However, mitigation measures are available to reduce or eliminate the risks from this hazard.

44. Several construction techniques are available which can mitigate the damage caused by lava flows; these include strategic siting, diversion berms and barriers, enclosed well cellars, evacuation planning, use of "bridge plugs", and decentralization of power plants to lessen the chance that one lava flow could damage a large capacity plant.

45. Geothermal pipeline supports can also be protected against lava flows by utilizing localized barriers or special support structures.

46. If a sufficiently large hill is not available for strategic siting, a plant or well could be protected by constructing an earth-and-rock platform ~~several~~ many meters high. Depending on the perceived risk from lava flow hazards, wells or plants can be ~~sufficiently~~ fortified to withstand ~~almost~~ most ~~any~~ lava flows.

47. Another well-protection alternative is to enclose the wellhead in a concrete cellar that would allow the lava to flow above rather than around the wellhead. Use of modern metallurgy, surface valves and blowout preventers ~~will~~ can also provide ~~further~~ security from potential lava flows.

48. Comprehensive evacuation plans can be implemented to assure worker safety. Procedures can be established to protect equipment and multiple access roads can be provided in the event one gets covered by a flow.

49. A ~~The~~ development ~~should~~ can coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory) and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. ~~The developers have been giving~~ this area their attention! already [illegible]

50. If a lava flow ~~is impending~~ ~~during~~ [illegible] well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing, portion of the well. These plugs can be installed in one hour.

51. Trip wires, placed in expected lava flow paths, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan.

Pyroclastic Fallout

52. The weight and depth of pyroclastic fallout can be appreciable ~~as far as~~ even ~~500 or~~ 1,000 meters away from an eruptive vent or fissure. Larger fragments tend to fall close to the vent, ~~building~~ cones ~~that~~ may ~~be~~ tens of meters high. Smaller particles can form a long, narrow blanket many feet thick downwind of the vent.

53. Prevailing easterly tradewinds are likely to carry fallout originating within the rift zone away from the Kilauea Middle East Rift Zone in a westerly direction.

54. In 1959, a blanket of pyroclastic fallout from Kilauea Iki vent in Kilauea's upper east rift zone extended approximately 3 km south of the rift.

55. Cooling Towers may be affected by pyroclastic fallout, but roofs can be designed and constructed to mitigate this potential impact.

56. Protecting structures or machinery against damage from pyroclastic fallout can be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong~~, having~~ a sufficient pitch ~~so that~~ pyroclastic fallout ~~does not~~ accumulate.

Ground Cracking and Subsidence

57. Ground cracking and subsidence related to magma movements are concentrated along volcanic rift zones which are narrow and clearly defined features along the entire Kilauea East Rift Zone.

58. Tectonic ground cracking is usually localized in definable zones such as in the Hilina and Koae fault systems.

59. Some cracks may not be positively identifiable because of existing forest cover.

60. Based on the frequency of cracks and eruptions, there would be a greater hazard at Kahaualea than there would be downrift.

61. Depths of surface cracks are unknown. Any cracks that develop below the caprock in a geothermal reservoir should not be a problem.

62. Most cracks are vertically pitched making it possible, but not probable, that a crack would intercept a vertical well-bore.

63. A fault could intersect a well-bore without causing any damage. The fault could seal off the well or the faulting could crimp the end of the casing and not allow the fluids to escape.

64. Contingency planning would include the best available methods for sealing a well-bore should a crack intercept a producing well.

65. No impact from cracks was experienced by any of the existing wells despite the fact that at least two of the six wells were sited close to surface cracks.

66. In Hawaii, subsidence from geothermal fluid withdrawal is not likely to be a problem, since the islands are generally composed of self-supporting basaltic rock.

67. Subsidence along rift zones are associated with magma intrusion. Intrusion of magma at Kilauea, sometimes leading to eruptions, often produce offsets of the ground along the rifts of the volcano.

68. Ground subsidence has historically been limited to the rift zone or to areas south of the rift zone.

69. Subsidence may be caused by fault displacement associated with tectonic activity along major fault systems such as Hilina.

70. Hazards from ground cracking and subsidence can be minimized by siting facilities away from the central rift zone and known surface cracks.

71. Installation of automatic well shut-off devices and pipeline block valves, in addition to constructing stream transmission piping with expansion joints, can mitigate hazards caused by appreciable subsidence and ground movements.

72. Geologic surveys should be utilized to ensure site stability for proposed development areas.

Earthquakes

73. Most earthquakes in Hawaii are volcanic in origin, and result from near surface magma movements. These earthquakes are small in magnitude and usually cause little direct damage.

74. Earthquakes are more frequent south of the east rift zone as substantiated by data collected by the Hawaiian Volcano Observatory.

75. The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana.

76. A November 1983 earthquake located in the Saddle area between Mauna Loa and Kilauea registered 6.6 on the Richter scale, but did not cause any damage to the HGP-A facility.

77. Geothermal facilities should be designed to resist the normal range of earthquakes which occur in Hawaii.

Tsunamis

78. Tsunami hazard is localized to a zone of land approximately 2 km wide around the coast and at elevations below 75 feet.

79. The proposed Kilauea Middle East Rift GRS is located at elevations generally above 1,400 feet and will not be impacted by tsunamis.

80. If geothermal development investors assume a major portion of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures to select sites which offer the optimum balance of safety and productivity.

81. The State in the conservation district or counties in the urban, rural, or agriculture districts may impose conditions to be met by the developers prior to the granting of permits.

82. The Board finds that the geologic hazards associated with geothermal development activities in the proposed Kilauea Middle East Rift GRS can be properly mitigated by developer action and subsequent government permitting.

D. Social and Environmental Impacts

83. Social and environmental concerns include air quality, water quality, noise, impacts to the community environment, ~~concerning~~ religious lifestyle, and cultural practices, aesthetic impacts and impact to flora and fauna. ~~present in the proposed GRS.~~

84. Social concerns generally involve health and noise aspects, potential changes to lifestyle, culture and community setting, and aesthetics. Social impact analysis should consider actual physical changes as well as people's perceptions, attitudes and concerns regarding geothermal resource development and operation.

85. The assessment of environmental impacts considers potential physical changes in air quality, surface and ground water quality, ambient noise conditions and impacts to flora and fauna within the GRS.

86. Potential impacts to flora and fauna may arise from changes in air quality, surface and ground water quality, ambient noise conditions, and may also be due to the actual physical disturbance of the area that plants and animals occupy, through outright destruction of the habitat, or the introduction of exotic species which displace native species.

Air Quality

87. The health aspects of air emissions from geothermal development involve the effects of chemical, particulate, and trace element emissions.

88. Environmental risks are due primarily to atmospheric emissions of noncondensing gases. Hydrogen sulfide, sulfur dioxide, particulate sulfate from the atmospheric oxidation of hydrogen sulfide, mercury, and radon are the major gaseous compounds and elements of concern.

89. Emissions of sulfur, mercury, and other volcanic gases are a continuous natural process along active volcanic rift zones, such as the Kilauea East Rift. Kilauea Volcano is known to emit 200 tons a day of sulfur dioxide. Quantification of pre-geothermal development concentrations of naturally occurring emissions is essential in order to assess any future changes in emission concentrations resulting from geothermal development.

90. Quantification of pre-geothermal development emissions has been undertaken by the State of Hawaii Department of Planning and Economic Development in a two-year environmental baseline survey, documented in a report entitled, "Baseline Air Quality, Kilauea East Rift".

91. The principal parameters measured in the baseline survey include atmospheric concentrations of particulate matter, sulfur dioxide gas, hydrogen sulfide gas, chlorine gas, carbon monoxide gas, elemental mercury vapor, radon, elemental, and organic content of the particulate material, rainwater pH, elemental and anionic content of rainwater, and wind speed and direction.

The study indicates the following ambient conditions:

a. Total Suspended Particulates (TSP) are very low and generally consist of sea-salt aerosal, road and soil dust, volcanic emissions, diesel exhaust and organic matter.

b. Sulfate particulate matter, and under certain conditions heavy metals contained in particulate matter can be related to volcanic emissions.

c. Current hydrogen sulfide and chlorine gas levels are very low and well below biological impact levels.

d. Occasional short-term hydrogen sulfide episodes at modest concentrations, but of short, less than a day, duration have been observed.

e. Sulfur dioxide concentrations due to volcanic activity can exceed for days at a time standard values, values typical of urban areas, and human health and plant impact values. Higher SO_2 values have been measured in the upper part of the Rift Zone than in the lower portion. In the absence of volcanic impact, SO_2 values are low.

f. Rainwater in Puna and Kau is slightly acidic. Acidification is due not only to volcanic emissions but also to long-range transport from sources across the Pacific.

g. All trace elements measurable were found to be below drinking water quality standards.

h. Ambient mercury and radon values were more or less typical of atmospheric values nationwide. However, the impact of volcanic emissions on the atmospheric radon content could be seen by noting the higher values measured at the site closest to the current eruption area in Kahaualea.

92. The State of Hawaii Department of Health has proposed Ambient Air Quality Standards to control hydrogen sulfide and particulate emissions from geothermal wells and hydrogen sulfide emissions from power plants. Although the standards initially proposed have been

withdrawn for the purpose of additional review, the Board expects that Ambient Air Quality Standards for geothermal wells and power plants will eventually be adopted.

93. Abatement technology has been described in the study, "Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii", prepared for the United States Environmental Protection Agency by the firm of Dames and Moore and published in January 1984.

94. The recommended H_2S abatement system, the "Stretford System", is capable of removing over 99% of the H_2S contained in the non-condensable gases.

95. The initial standards proposed by the State Department of Health for geothermal developments required removal of 98% of the H_2S present. Use of the Stretford system would enable facilities to comply with the initially proposed standard.

96. An assessment of potential air quality emissions was made utilizing data gathered at the operating HGP-A well and power plant site, under the assumption that BACT would be utilized in addition to EPA-developed air dispersion models. Based on these calculations, potential H_2S emissions during normal power plant operations, for both a 25 and 50 megawatt plant, were found to be well below the initially proposed Hawaii Ambient Air Quality Standard for H_2S.

97. H_2S emissions during well bleeding operations have the potential to exceed proposed ambient air quality standards. This potential can be eliminated by developing and implementing measures for use during well bleeding operations.

98. Given the characteristics of the HGP-A reservoir fluids and the BACT required to comply with proposed state air quality standards, geothermal facility cooling tower emissions are not expected to be

toxic and the plume of the cooling tower would consist entirely of water vapor. Brine from the plant will be reinjected back into the geothermal reservoir.

99. Abatement of Radon-222 is unnecessary since the level emitted from the geothermal power plant is lower than most indoor levels where cement in buildings emit radon.

100. Calculations of potential particulate and trace element emissions on ambient air quality were prepared as a part of the "BACT" study. This data indicated that a project similar to that initially proposed at Kahaualea does not have the potential to exceed applicable EPA air quality guidelines for these compounds.

101. Utilization of the best available control technology, such as the Stretford System, or a burner-scrubber system, will reduce the emissions from geothermally generated electricity to levels far below that generated by more conventional fossil fuel electrical energy production currently in operation today in Hawaii.

Water Quality

102. Although the Kilauea Middle East Rift zone has no perennial streams, surface disposal of geothermal fluids would not be permitted.

103. Geothermal fluids, most of which have a total dissolved solids content greater than 1000 ppm are commonly disposed of by reinjection into the geothermal reservoir.

104. Ground water will not be adversely affected because geothermal wells and reinjection wells are drilled past ground water aquifers and surface casing is set and cemented through a competent subsurface formation below the basal water lens.

105. The drilling, casing, installation, maintenance, and abandonment of all geothermal and injection wells will be regulated and monitored to protect the ground water aquifer.

106. The State Department of Health has established an Underground Injection Control (UIC) program designed to protect the state's underground sources of drinking water under Chapter 340 of the Hawaii Revised Statutes. This law regulates all types of underground injection including geothermal fluids, such that underground sources of drinking water will not be polluted.

Noise

107. Noise from the development and operation of a geothermal facility is generated by three sources: (a) construction of roads, pipelines, powerlines and buildings; (b) geothermal well drilling and well testing or venting; (c) geothermal power plant operations.

108. Noise generated by construction activity usually involves use of standard construction equipment such as bulldozers, trucks, and graders over a limited time period and ranging from 40 to 125 decibels, depending on the distance from the well or power plant site.

109. Within 100 feet of a drill rig, the noise generated will vary between 60 and 98 decibels with the use of a noise muffler.

110. Initial well venting or testing noise varies from 90 to 125 decibels; however, this noise can be mitigated by use of a stacked pipe insulator or cyclone muffler. Periodic operational well venting would generate about 50 decibels using a pumice filled muffler.

111. Power plant noise levels are expected to be low and should result in slightly audible noise or none at all at most receptor sites.

112. Although noise levels associated with geothermal development and operation are comparable to industrial and electrical power plants of similar size, a continuous noise level of 75 dBA at 100 feet from the power plant is considered to be readily achievable.

113. The impact and intrusiveness of noise from geothermal operations is dependent on the meteorological conditions, the intensity of the noise source; the sound propagation, conditions existing between the source and the listener, the ambient noise at the receptors, as well as the level of activity in the vicinity of the receptor at the time the noise is generated.

114. Ambient noise levels are expressed as day-night noise levels (Ldn) where a 10dB reduction is given for noise levels during the night-time period between 10:00 pm and 7:00 am.

115. The long-range strategy of the U.S. Environmental Protection Agency is to achieve a goal of 55 Ldn (45 dBA) which will ensure protection of public health and welfare. The Environmental Protection Agency's "Protection Noise Level" recommends noise levels, which have been defined by a negotiated scientific consensus developed without concern for economic and technological feasibility and intentionally conservative to protect the most sensitive portion of the American population including an additional margin of safety. These levels can be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise.

116. In May 1981, the County of Hawaii Planning Department issued its "Geothermal Noise Guidelines" to provide proper control and monitoring of geothermal-related noise impacts. These guidelines set standards that are stricter than those standards used on Oahu and statewide, because of the lower existing ambient noise levels evident on the island of Hawaii.

117. The County of Hawaii geothermal noise guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted.

118. The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels; however, construction of a rock muffler at the facility has reduced noise levels to 44 decibels at the project fence line.

119. The type of housing common in and nearby the Kilauea East Rift, as found in the Fern Forest and Volcano communities, will result in further reduction of noise levels, from outside to inside of at least 15 decibels. Thus, an outside noise level of 45 dBA will reduce to an inside level of 30 dBA or less, which is lower than the Environmental Protection Agency's 32 dBA level for sleep modification.

120. The Board therefore finds that noise associated with geothermal development can be effectively mitigated to comply with the County of Hawaii noise guidelines for geothermal development.

<u>Lifestyle, Culture and Community Setting</u>

121. Potential changes to the lifestyle, culture and community setting represent a major social concern of Puna residents.

122. Although health and noise impacts may be adequately mitigated, Puna residents tend to perceive geothermal development as an introduced change leading toward industrial and urban development of Puna's essentially rural environment.

123. Community surveys completed in 1982 reveal a wide range of perceptions about geothermal development. While some residents believe their health has been affected by geothermal development, others find

only the odor from geothermal facilities to be objectionable. Some residents perceive geothermal development as neither good or bad for Puna, while others readily balance potential economic benefits with the environmental and social costs.

124. Surveys also reveal those aspects of life in Puna that residents value. Puna residents seem to prefer the rural, uncrowded, country-like atmosphere of Puna, its aesthetic physical environment and its characteristic lifestyle.

125. Surveys further reveal that some Puna residents engage in traditional subsistence activities, such as hunting and gathering of food and collection of medicinal plants and maile (a scented shrub used in traditional leis) in areas which may be developed for geothermal facilities. Such activities could be minimally affected by geothermal facility development.

126. Although the proposed GRS presently serves no known economic use except for limited plant gathering, it does provide open space for residents of adjacent residential and agricultural subdivisions. A portion of the GRS is planned for use by geothermal facilities; however, this loss of open space will be offset by the designation of the pristine native forest at Kahaualea as a natural area reserve and the expansion of Volcanoes National Park through the acquisition of Tract 22 forming an uninterrupted large open space open to public use.

127. The Puna district has experienced changes in lifestyle, culture and community setting in recent years due to the influx of new residents. New residents associated with geothermal development are expected to contribute in a minor way to the lifestyle, cultural and community changes already evident in Puna.

128. Designation of the Kilauea Middle East Rift as a geothermal resource subzone and subsequent development of geothermal facilities

can be accomplished with the proper controls, designed to minimize the industrial aspects of such a facility.

129. The Board finds that social impacts can be minimized and a quality rural environment maintained in Puna, by the proper siting of facilities, landscaping, aesthetic facility design, and through the control and monitoring of air quality and noise.

Historical and Archaeological Values

130. Development of geothermal facilities by site clearing and facility construction runs the risk of destroying historical and archaeological sites.

131. Evidence of prehistoric cultural activities and features such as foot trails, upland taro patches and planting areas, a pulu factory, and other historical sites have been reported in areas adjacent to the GRS; however, there are no known archaeological sites in the Kilauea Middle East Rift Zone.

132. Estimates of potential impacts can be made by plotting known archaeological and historical sites, completing an archaeological and historical literature search, and by archaeological reconnaissance surveys.

133. These surveys are best employed when specific sites for geothermal facilities, roads and pipelines have been identified. If any sites are then discovered during the survey, the location of the geothermal facilities, roads, and pipelines can be adjusted to minimize impacts or avoid sites completely.

134. The Board finds that potential impacts to archaeological and historical sites can be minimized by completing archaeological and historical literature searches, plotting all known sites and completing archaeological reconnaissance surveys. If archaeological or historical

sites are found they can be described and assessed as to their significance, and measures taken to ensure their protection during subsequent permitting processes.

The Practice of Native Hawaiian Religion at Kilauea

135. The current day practice of Native Hawaiian religion includes the worship of the goddess Pele. Many native Hawaiians regard Pele as an akua (god) or as aumakua (family or personal god). Some native Hawaiians also identify themselves as the bloodline of Pele. Hawaiians who actively worship the goddess Pele have been identified as "Pele practitioners".

136. Pele practitioners believe Pele is a living god, whose presence is manifested in periodic and frequent volcanic eruptions. Pele is believed to also be present in the sacred area surrounding the Kilauea Volcano in kino lau (alternate body forms) such as ferns, certain shrubs and trees, and certain volcanic land forms or features, such as significant pu'u (hills).

137. Pele practitioners believe that the area of active volcanism is in fact Pele's physical body, her home or abode. There was testimony from some [illegible] ~~Pele practitioners~~s believe Pele's home encompasses an area extending from Mauna Loa through the Kau and Puna districts to the ocean, including the entire area of the Kilauea Volcano and the East and Southwest Rift Zones.

138. To Pele practitioners, Pele is also the heat, water, steam, smoke, and vapor present in and throughout the Kilauea Volcano and its rift zones.

139. Pele practitioners worship Pele by making offerings to her. The specific details of how and where such offerings are made were not presented to the Board during the contested case hearing. There was some testimony ~~Pele practitioners instead~~ indicat~~ed~~ing that Pele is a spiritual concept central to

(the believers

the
~~their~~ lives and psychological survival, and that Pele provides inspiration, strength and a focus for their lives.

Two   ed   that

140. Pele practitioners ~~did~~ testify ~~regarding activitie~~s they consider impermissible within the area considered to be Pele's abode. They ~~Pele practitioners~~ believe that geothermal exploration and development is an offense against Pele, a desecration of her body and being, because this activity involves drilling into Pele's body and removing her energy. They ~~Pele practitioners~~ believe this activity will take Pele and kill her forever.

Two   testified that they

141. Pele practitioners ~~also~~ believe that offenses against Pele will cause Pele to retaliate violently in the form of volcanic eruptions, earthquakes and tsunami. They ~~Pele practitioners~~ indicate they fear for their lives and the lives of their children.

Two   testified that they

142. Pele practitioners believe that geothermal exploration and development will threaten and probably prevent the continuation of all essential ritual practices associated with Pele and thereby impair the ability of Pele practitioners to train young Hawaiians in the traditional Hawaiian beliefs and practices. They believe therefore that Hawaiian religion and culture will not be conveyed to future generations and will therefore die.

found

143. The Board ~~has found~~ that not all Hawaiians share the beliefs of Pele practitioners. Other Hawaiians currently believe that the development of geothermal energy is not counterproductive to native Hawaiian culture and heritage. One of these native Hawaiians has stated that, "...as a Hawaiian who shares the love of this land with others, cognizant of my heritage and traditions, I feel my ancestors would be proud to know that we are trying to use our natural resources in the best way possible. The Hawaiian of times past, with his astute knowledge of all things and through the proper observances of established laws, used all of the natural resources available in their limited way to do the most good for the most people." cite

144. Historical accounts of native Hawaiian activity show that early Hawaiians did use geothermal steam for cooking food for non-religious purposes.

145. Early Hawaiians are recorded using steam emanating from fissures along the rift zone for personal uses as well as religious uses. William Ellis, in his journals, notes that the ground in the vicinity of Kilauea throughout the whole plain was so hot that those who can came to the mountains to gather wood and to fell trees and hollow them for canoes "always cooked their own food, whether animal or vegetable, simply by wrapping it in fern leaves and burying it in the earth", a method quite similar to the Hawaiian imu (an underground oven).

146. At Kilauea on Hawaii, Handy and Handy, in their "Native Planters in Old Hawaii" describes how whole trunks of hapu'u pulu (fern trees) were thrown into steam fissures, covered with leaves, and when cooked, were split open and the starch core used as food for pigs.

147. The Board also notes that Mr. Don Mitchell, a noted author on Hawaiian history, does not believe that ancient Hawaiian beliefs were specifically against the use of steam, but that it is only a recent interpretation of Hawaiian theology. He believes that ~~steam is not referred to in early discussions of Pele but that~~ lava and volcanic eruptions are ~~more~~ closely associated with Pele, but that steam was not referred to in early discussions of Pele.

148. Other people speaking on behalf of Hawaiian civic groups have spoken in support of geothermal development. The president of the Hawaiian Civic Club in Kau is quoted regarding their support of the designation of a geothermal resource subzone; "...we are not living in the past now. There's a lot of things we need to preserve, and yet there's a lot of things that sometimes we have to give up for the betterment of our own Hawaiian children and families. Now, me, speaking on behalf of myself, talking about geothermal, I cannot say

traditions and practices

that I know too much about geothermal. But I think I know enough that I would sit here and support the geothermal resource subzone..."

149. ~~As such,~~ The Board concludes that there are a variety of ~~other points of~~ religious beliefs ~~view~~ held by native Hawaiians ~~that should be considered~~. Many beliefs very strongly held. Some have well recognized

150. The Testimony presented by Pele practitioners ~~is essentially a matter of~~ represents their faith and personal beliefs which can neither be accepted or rejected by the Board. ~~Potential impacts to religious belief cannot be mitigated.~~ The Board ~~therefore believes~~ finds that the religious concerns of native Hawaiians ~~command~~ deserve respect and care should be exercised ~~to enhance and~~ not to harm the genuine religious ~~aspects~~ practices associated with Kilauea Volcano and the East Rift Zone.

151. ~~Furthermore, the Board maintains that~~ A GRS establishes ~~an area~~ geographic ... where applications for geothermal exploration and ~~eventual~~ development may be considered. It is only the first ~~level~~ step that identifies areas that may be appropriate for geothermal development. It does not authorize any activity on the ground nor does it interfere with anyone's use of the land. It does not prohibit any religious ... nor ban any belief.

152. The Board finds that the initial identification of an area on a map and designation of that area as a GRS does not in any way prohibit religious practices on land located in the middle east rift of Puna. Individuals may continue to freely exercise whatever religious practices they have observed in the past.

Scenic and Aesthetic Values

153. Geothermal resource development located in remote wilderness areas may represent a visual intrusion. However, the extent of the intrusion depends on the specific location and structure involved since the proposed GRS contains both open lava flows where a power plant might be visible, as well as heavily forested areas where an installation would be relatively unobtrusive.

154. Where a facility would be visible, structures can be attractively designed, landscaped, and painted to blend with the surrounding natural setting.

155. Depending on the terrain within and adjacent to a power plant site, an analysis of view corridors should be prepared to estimate potential visual impacts for subsequent permit processing by state and county agencies.

156. In addition to structures such as power plants and cooling towers, under certain atmospheric conditions warm air from the cooling tower will condense as it rises to form a small cloud similar to that often observed near cracks and puu along the remote part of the east rift zone east of Mauna Ulu. During normal atmospheric conditions, no visual vapor are expected from cooling towers.

157. The Board concludes that the natural beauty of the area contained within the proposed GRS can be aesthetically maintained ~~by~~ through mitigation measures including
the careful siting of geothermal facilities.

Impact to Native Vegetation

158. Vegetation in Hawaii's geothermal resource areas have been described in baseline surveys prepared for the Hawaii State Department of Planning and Economic Development by the University of Hawaii Department of Botany, in the report, "Puna Geothermal Area Biotic Assessment, Puna District, County of Hawaii", published in April 1985.

159. Within the proposed GRS, different vegetation types occur in a mosaic pattern reflecting lava flows of different ages and different degrees of past disturbance. Extensive areas of ohia-uluhe woodland, ohia forest and recent lava flows are interspersed with small patches of ohia forest, designated, ohia-a(1), ohia-a(2), ohia-a(3) and ohia-b forests.

160. ~~The assemblage of~~ Bare lava and various native plant communities throughout the Kilauea rift zone ~~are environmentally significant in that these~~ create biologically rich and dynamic communities which ~~demonstrate the development of~~ provide an plant succession on lava flows, serve as habitat for native species and have been found to contain two additional ecosystem types--the lava tube ecosystem and the neogeoaeolian ecosystem. (Findings relating to specific ecosystems are covered separately in subsequent sections of this document.)

161. ~~The~~ Specific vegetation ~~types~~ areas found in the Kilauea Middle East Rift are described as follows:

(i) Lava Flows. The most recent lava flows, still largely unvegetated, are those from the 1983-85 Pu'u O'o flows. The~~re are also~~ 1977 and 1955 lava flows ~~which~~ support early successional stages with scattered young ohia plants and a mixture of common native and introduced species.

(ii) Ohia-uluhe woodland. This ~~is a~~ forest ~~which~~ probably represents a later successional stage than (i) above. It consists of scattered ohia trees with an almost continuous carpet of uluhe fern. There are a few other native plants present, such as kopiko and 'uki. Introduced species such as malabar melastome and bamboo orchid are common.

(iii) Ohia forest ~~types~~. ~~These represent still~~ This is a later successional stage~~s~~. Four ~~such~~ types were recognized:

(1) Wet ohia forest with native species (ohia-a(1))

These forests have tall ohia trees, usually more than 30 feet, with a nearly closed canopy. There is a subcanopy layer containing a number of native trees, and a third layer of hapuu tree ferns, plus a ground cover of ferns and small shrubs. Very few introduced weeds ~~occur~~ are found in ohia-a(1) forests.

(2) Wet ohia forest with native species and exotic shrubs (ohia-a(2))

in that [illegible]

These forests differ from ohia-a(1) ~~by~~ contain~~ing~~ a large number of introduced species in the shrub and subcanpoy layers. Strawberry guava and malabar melastome are the major introduced species. The presence of these introduced plants indicates that these forests are more highly disturbed than ohia-a(1) forests.

(3) Ohia-kukui forest with mixed native and exotic shrubs (ohia-a(3))

This differs from ohia-a(2) by containing an admixture of the kukui, a tree introduced by the Polynesians. Other plants found here, such as 'awa and ti, suggest that these areas were probably utilized by the Hawaiians in former times.

(4) Ohia forest with exotic subcanopy and shrub layers (ohia-b)

These are ohia forests which have been greatly disturbed in the past and in which the subcanopy layers consist largely of introduced species.

162. Ohia-a(1) forest is the most intact forest type with the largest component of native species and is therefore the type which would be most sensitive to disturbance. Ohia-a(1) forest is found in small to moderate sized patches in the southwest part of the subzone as islands surrounded by ohia-a(2) forest or lava flows.

163. Ohia-a(2) forests cover extensive areas of the western portion of the subzone and are interspersed with extensive ohia-uluhe areas in the northeastern portion of the subzone. Large ohia-uluhe areas cover the eastern portion of the subzone, while lava flows dissect the western and central portions of the GRS.

164. Development of geothermal resources in forested areas may have the following detrimental effects:

a. Direct loss of habitat and destruction of native organisms, as a consequence of land clearing during the construction of access roads, pipelines, wells, power plants and transmission lines.
b. Acceleration of invasion of introduced plants and animals which move into the disturbed habitats created during development.

c. Compaction of soils due to construction activities may permit ponding of water providing additional breeding sites for mosquitos that are vectors for avian malaria.

d. Physical damage to plants during construction and maintenance activities which may lead to infection by pathogens and the spread of plant disease.

e. Emissions from geothermal wells and plants may differ sufficiently from natural emissions to which plants have adapted and may ~~be found to~~ have a detrimental effect on these species.

165. These effects can be mitigated by avoiding, as much as possible, land clearing in highly sensitive areas that support forests dominated by native species such as ohia; by locating access roads and drilling sites on recent, less densely vegetated lava flows; and by disturbing the smallest area possible during construction.

166. Recent observations of old lava flows within the Kahaualea area indicate that invasion of exotic species--the edge effect--does not extend more than 50 to 100 feet from a disturbed area. Therefore the effects of land clearing are not expected to extend much beyond the edge of the cleared area.

167. Nonetheless, the introduction of exotic species should be minimized in disturbed construction sites by continual monitoring of developed areas and utilization of an effective and environmentally compatible method of weed control appropriate to specific sites.

168. Construction sites can be monitored to assure that site drainage remains unimpeded. Bulldozing and site maintenance work can be carried out so as to minimize damage to native plants.

169. Native species in geothermal areas have by evolution adapted to the air quality conditions found naturally along the Kilauea East Rift. However, State air quality standards will assure that geothermal well and power plant emissions will be well below amounts released

during eruptions and probably well below amounts necessary to cause damage to native flora.

170. The geothermal resource subzone establishes an area where application for geothermal exploration and eventual development may be considered. Establishment of a subzone is only the first step in identification. It does not authorize any activity on the ground.

171. Site specific information on any geothermal development proposal ~~is~~ necessary to accurately predict impacts on native forest ecosystems.

172. Therefore, mitigation of potential impacts to specific forest areas is best undertaken during subsequent permitting processes when the geothermal facility layout and construction details have been proposed.

173. Nonetheless, some impact to the native forest present in the Kilauea middle east rift is likely; however, facility layout and design can be adjusted during subsequent permitting processes to minimize impacts to the more environmentally sensitive areas of the forest.

Impact to Unique Ecosystems

174. Three unique ecosystems have been identified in the Kilauea East Rift area: the successional ecosystem, the lava tube ecosystem, and the neogeoaeolian ecosystem.

175. Each successive volcanic eruption spills new lava onto geologically older surfaces. Since Kilauea Volcano is active, surfaces may be only a few hours old, a few days, weeks or months old; ~~however,~~ some flows may be over 100 years, or even over 500 years old.

176. Lava flows of different ages are in various stages of being colonized by plants. Plant community development is known as forest succession.

177. Development stages are not arranged in any specific set pattern, but are an indeterminant patchwork or mosaic of different sizes and variable-aged flow pieces, often referred to as kipuka.

178. Development of vegetation on kipuka is influenced by moisture, lava flow frequency, proximity to other kipuka and elevation.

179. Moisture is the most important determinant influencing the rate of vegetation succession on volcanic substrates. Most of the Kilauea East Rift consists of windward slopes that provide moist and wet conditions, depending on elevation and exposure to tradewinds.

180. Wet forests have different species composition than moist forests adding to the species diversity present in kipuka.

181. High lava flow frequency such as that exhibited at Kilauea, provide a variety of lava flow ages and surfaces insuring a full range of successional vegetation.

182. Small kipuka of variable age in close proximity to one another aid the dispersal of organisms and thereby maintain the successional development.

183. Suitable lava flows, environment and mosaic arrangement of kipuka that encourage successional development are generally found along and downslope of the Kilauea East Rift, ranging from Mauna Ulu to the west in the Hawaii Volcanoes National Park extending east and down rift to Heiheiahulu in the Wao Kele O Puna Natural Area Reserve and somewhat intermittently to the east of the NAR. The mosaic area extends from the northern boundary of the Kilauea East Rift to the Kalapana Trail to the south, except where it has been truncated by bulldozing or woodchipping activities or residential development.

184. Successional ecosystems along the Kilauea East Rift range from new lava flows, essentially devoid of life, through the

development of wet and dry forest assemblies of plants to mature ohia and lama forests.

185. The number of species of plants and animals and the variety of communities is high for the small geographic area that contains kipuka. Portions of the east rift are therefore considered to be biologically rich and dynamic.

186. Although kipuka individually and collectively represent successional ecosystems, new lava flows renew the successional development; therefore successional ecosystems are not necessarily unique, nor short-lived, but conditions for their development are constantly being renewed with each new eruption that brings fresh lava to the surface.

187. Two additional ecosystems are found within the successional ecosystem mosaic area, the subterranean lava tube ecosystem, and the neogeoaeolian ecosystem. Both systems are dominated by arthropods, rather than plants.

188. The subterranean lava tube ecosystem exists within the surface or near the surface of pahoehoe flows that have developed an ohia forest upon them. Highly specialized insects and spiders live in the dark and damp lava tubes and cracks beneath the pahoehoe flows. These insects co-habit and can exist as long as they have contact with living ohia roots and the tubes and fissures remain open, cool, dark and damp.

189. The neogeoaeolian ecosystem occurs on recent barren or very sparsely vegetated lava flows and depends on the aerial drift of arthropods from adjoining vegetated flows and kipuka providing the ecosystem's source of energy. Crickets and spiders in these areas eat each other and waif arthropods that drift or fly across the flow or are killed or marooned by the harsh surface conditions present.

190. This ecosystem is transient and dependent on periodic renewal of fresh lava surfaces since natural forest succession ameliorates the harsh surface condition and diminishes the scavengeable waif food supply that is the ecosystem's energy source.

191. The Wao Kele 'O Puna Natural Area Reserve includes a portion of the successional ecosystem area along its southern border. The northern portion of the NAR provides a protective buffer for the successional ecosystem. The successional ecosystem area is also protected by the Kahaualea area located to the northwest.

192. Geothermal development will include certain activities that create openings in the forest. These openings may result in alterations in the light, temperature and the humidity regimes at the edges of openings, leading to changes in the vegetation.

193. The extent and nature of this "edge effect" may vary with the size of the area cleared. Recent observations of old lava flows within the Kahaualea parcel indicate the edge effect would not extend more than 50 to perhaps 100 feet away from the clearing. Therefore the effects of clearing areas for well sites, roads, and power plants are not likely to extend much beyond the edge of the cleared area.

194. The mosaic nature of the vegetation allows a geothermal developer to site projects such that the most sensitive vegetation types and species ~~are~~ can be avoided as much as possible.

195. Disturbance of mosaic areas can be minimized by siting proposed geothermal facilities on recent lava flows or in ohia-uluhe forest areas.

196. Development of geothermal facilities could be allowed within the mosaic area, provided the most highly sensitive portions of the mosaic area were avoided without any significant impact on long-term vegetation succession.

Impact to Invertebrates

197. Certain insect species such as the Hawaiian drosophila illustrate the dynamic evolutionary processes, the study of which constitutes basic biological research which can lead to successes in applied situations. For example, basic work with Hawaiian drosophila has lead to more effective control programs for fruit flies.

198. Genetic engineering can utilize specific genes from species to modify reproduction in other similar species. For example, Hawaiian drosophila genes can be translocated to other fruit flies so as to produce all males in subsequent generations, thereby diminishing the fruitfly population, potentially yielding great economic benefits worldwide.

199. More than 500 species of the endemic Hawaiian drosophila have been collected and described. There are another 100 to 300 species of this fly which are known but as yet are undescribed.

200. Unique species of drosophila have been found throughout the State of Hawaii. There may be unique species of drosophila to be found in the middle east rift zone.

201. Native ecosystems where drosophila may exist should be kept intact in order to preserve the genetic resources that may be there.

202. The mosaic ecosystems, also kniown as kipukas in the Kilauea Middle East Rift Zone, represent 7 or 8 different forest types. These ecosystems give rise to unique genetic variances because gene pools present in kipukas have become isolated and there is very little gene flow between kipukas since drosophila will not cross over lava flows even a few hundred yards wide.

203. The southwest corner of the Wao Kele 'O Puna Natural Area Reserve contains kipuka which exhibit mosaic ecosystems that may give rise to genetic variations among drosophila.

204. Exclusion of kipukas and the mosaic ecosystems they contain would prevent the use of geothermal resources located below the kipuka. However, use of directional drilling techniques can develop the geothermal resource below kipuka areas without disturbing the surface environment. Directional drilling can be utilized in developing the geothermal resource in the Kilauea Middle East Rift.

205. Further protection of surface features such as kipuka can be provided during subsequent permitting processes when specific development plans have been provided and the approximate location of facilities are known. At that time, facility locations can be adjusted to avoid kipukas.

Impact to Endangered Native Avifauna

206. Native forests along the Kilauea East Rift provide habitat for a number of Hawaii's endemic birds, as well as indigenous and exotic bird species.

207. Endemic, indigenous and exotic bird species known to be present in and along the Kilauea East Rift have been described in baseline surveys prepared for the Hawaii State Department of Planning and Economic Development by the University of Hawaii, Department of Botany in the report, "Puna Geothermal Area Biotic Assessment", Puna District, County of Hawaii, published in April 1985.

208. Endemic species are those that are unique to Hawaii and do not naturally occur elsewhere, while indigenous species are those whose total range in the Pacific Ocean includes Hawaii; exotic or introduced species are those that have been brought to Hawaii by man.

209. Some endemic species have been classified as endangered species by the U.S. Fish and Wildlife Service. Essential habitat needed to ensure their recovery to a non-endangered status have also been defined.

210. The U.S. Fish and Wildlife Service conducted a census of native forest bird species found in the Puna Forest Reserve and the Wao Kele O Puna Natural Area Reserve in 1979. This information was compiled in the Hawaii Forest Bird Recovery Plan which proposed essential habitat areas for native forest birds.

211.Essential habitats have been defined for all endangered forest birds on the island of Hawaii and for the Nene. The Recovery plan is subject to modification as dictated by new findings and changes in species status and completion of tasks enumerated in the Plan.

212. Three endangered species, the Nene, the I'o and the O'u have been sighted along the Kilauea East Rift zone.

213. The present range of the Nene is from approximately 3800 to 8000 feet elevation on the slopes of Mauna Loa. Nene are not known to occur in the GRS.

214. The I'o or Hawaiian Hawk occupies a broad range of habitats from papaya and macadamia orchards to virtually all types of forest including ohia rain forest and the sub-alpine mamane-naio woodland, and ranges from sea level to 8500 feet elevation.

215. The I'o is classified as endangered; however, some researchers maintain this classification should be re-evaluated since the species has proven to be abundant, widely distributed and highly reproductive. The 1984 population estimate for the wild I'o range from 1400 to 2500 birds.

216. The I'o is very adaptable and forages for food, feeding on spiders, insects, mammals, and on both native and introduced birds. The I'o does occur in the GRS and has been sighted between 1500 and 2400 feet elevation.

217. Although the I'o is wide ranging and adaptable, it is fairly sensitive to human disturbance when nesting. However, its nests have never been found at either the Kilauea Middle East Rift or at Kahaualea.

218. Site surveys prior to development should ensure that no nesting I'o are disturbed should these birds be found nesting in the GRS.

219. O'u essential habitat is that area along the East Rift above the 2000-foot elevation contour including the Kahaualea area. A small portion of the northwest corner of the GRS overlaps the O'u essential habitat area; however, there have been no recorded sightings of O'u within the GRS.

220. The threatened sea bird, the A'o (Newell's Shearwater) may also use the State Forest Reserve lands for nesting. An adult A'o and egg were found at Makaopuhi Crater in 1975; however, the only large known nesting grounds for the Shearwater are on Kauai. No live colony of A'o have ever been found in the area of the GRS.

221. The Board concludes that development of geothermal facilities above the 2000-foot elevation contour near the northwest corner of the proposed GRS could affect the O'u since this portion of the GRS overlaps the essential habitat of this species. However, there have been no recorded sightings of any endangered or threatened species within the GRS, and protection of native arifauna can be accomplished during subsequent permitting when the location of proposed facilities are known.

Impact to Endangered Plant Species

222. The "Puna Geothermal Area Biotic Assessment", published in April 1985 by the University of Hawaii Department of Botany, indicates that a number of plant species found within the East Rift zone are listed as either Category 1 or 2 candidate species for listing as endangered by the U.S. Fish and Wildlife Service.

223. Category 1 species are those for which the Service has sufficient information to support the biological appropriateness of listing the species as endangered, but for which data still need to be collected concerning the environmental and economic impacts of listing and designating a critical habitat for that species.

224. Category 2 species are those for which the Service has information indicating probable appropriateness of listing as endangered or threatened but for which sufficient information was not yet available to biologically support the listing.

225. Of the nineteen Category 1 species collected in the University's survey, only two are found within the proposed GRS, Bobea timonioides and Cyanea tritomantha.

226. Bobea timonioides or 'ahakea, a medium stature tree 6 to 8 meters tall, occurs in the GRS principally in the ohia-a(1) and ohia-a(2) forests. It is a Category 1 species which was sighted at 3 locations in the central portion of the GRS and at two sites along the lower east rift outside the proposed Kilauea Middle East Rift GRS. The plant has also been sighted in the Kapoho GRS.

227. Cyanea tritomantha or 'aku'aku, also a Category 1 species, has white flowers in dense clusters and leaves and stems covered with almost translucent prickles. This plant was sighted in the northeast corner of the GRS.

228. The endemic fern, <u>Adenophorus periens</u>, also a Category 1 species has been sighted to the north and west of the GRS in the Kahaualea area and the upper portion of the Wao Kele 'O Puna Natural Area Reserve.

229. During a 1979 U.S. Fish and Wildlife Service survey, one tree with a clump of Adenophorus periens ferns was sighted in the GRS. It may occur elsewhere in small numbers in the western portion of the GRS; however, none has been sighted to date.

230. Site surveys can be accomplished during subsequent permitting processes when development details are known. Roads, wells, power plants and other geothermal facilities can be sited so that they avoid areas where endangered plants are found.

E. Compatability of Geothermal Development and Potential Related Industries with the Present Uses of Surrounding Land and those Uses Permitted Under the General Plan or Land Use Policies <u>of the County in which the Area is Located</u>

231. The proposed Kilauea Middle East Rift GRS, consisting of 11,745 acres is located within and adjacent to the Wao Kele 'O Puna Natural Area Reserve and the Puna Forest Reserve.

232. The Puna Forest Reserve and Wao Kele 'O Puna NAR surround the GRS on the north and west consisting of ohia forest on the north and ohia forest interspersed with lava flows on the west (Kipuka mosaic area). Ohia-uluhe and ohia forest are found along the southern boundary and eastern boundary. Agricultural lands are present along the eastern boundary of the proposed GRS, where they abut the existing Kamaili GRS forming a contiguous GRS land use designation.

233. Most of the land within and surrounding the proposed GRS is designated by the State Land Use Commission as Conservation District,

with the exception of the extreme east and southeast portion of the proposed GRS that has been designated as an Agricultural District.

234. Conservation District land uses are administered by the Department of Land and Natural Resources under the Department's Administrative Rule, Title 13, Chapter 2. The County General Plan recognizes that conservation lands are administered by the BLNR. County General Plan, p. 3.

235. The urban, rural, and agricultural state land use districts are administered by individual counties through their general plans, which set forth County objectives and policies for long-range development and through their community plans which provide more detailed schemes for implementing general plan goals and policies.

236. Act 296, SLH 1983, as amended by Act 151, SLH 1984, allows the designation of geothermal resource subzones within urban, rural, agricultural and conservation state land use districts established under Section 205-2, HRS.

237. Uses permitted within agricultural districts include alteration of crops, orchards, forage and forestry; farming activities or uses related to animal husbandry, game and fish propagation; services and uses accessory to the above noted activities, including, but not limited to, living quarters and dwellings, mills, storage facilities, processing facilities, maintenance facilities and roadside stands for the sale of agricultural products. Agricultural parks and open area recreational facilities, public, private and quasi-public utility lines and roadways, transformer stations, communications equipment buildings, solid waste transfer stations and major water storage tanks, and wind energy facilities where they are compatible with agricultural uses and cause minimal adverse impact.

238. Agricultural district lands within the GRS are under the jurisdiction of the County of Hawaii. The County of Hawaii has permitted the drilling of geothermal wells in lands zoned agricultural near the existing HGP-A geothermal facility in Puna.

239. The County ~~will~~ may assess, upon applications for, specific geothermal facility development on agricultural zoned lands during ~~the~~ any subsequent permitting processes.

240. The County of Hawaii's General Plan states specific goals for energy. These are:

(a) to strive toward energy self-sufficiency for Hawaii County, and

(b) to establish the Big Island as a demonstration community for the development and use of natural energy resources.

241. The Hawaii County plan encourages the development of alternate energy resources, promotes a proper balance between the development of alternate energy resources and environmental preservation and encourages the use of new energy sources.

242. The ~~ptp½pdrf~~ proposed designation of the Kilauea Middle East Rift GRS is consistent with and implements ~~the~~ objectives ~~of~~ in the County of Hawaii General Plan.

243. Mitigation of any adverse impacts can be accomplished during subsequent permitting processes when specific locations have been determined for geothermal facilities.

F. Potential Economic Benefits to be Derived from Geothermal Development and Potential Related Industries

244. The State of Hawaii depends upon petroleum supplies for 91.4 percent of all the energy consumed in the State. The oil that Hawaii imports costs the State about $1.5 billion per year in funds which flow out of the State for this purchase. As a consequence of the high cost of imported fuel, electricity rates in Hawaii are among the highest in the nation.

245. The Department of Planning and Economic Development believes that geothermal energy is the largest, near-term baseload electric energy resource for Hawaii. Large scale development of geothermal resources on the Big Island is essential to the State and County of Hawaii in attaining their objectives of energy self-sufficiency.

246. About 60 percent of the total energy produced on the Big Island is generated from fossil fuels such as industrial and diesel oils. Due to the uncertainties of the price and supply of fuel oil, HELCO is seeking to ultimately meet electrical system demands solely from renewable energy sources such as geothermal energy. To become energy self-sufficient and not dependent on fossil fuel, the County of Hawaii would need over 100 megawatts from alternative sources.

247. The current investigation regarding the feasibility of an interisland cable suggests that a substantially larger market, Oahu and the other islands, could be supplied by geothermally generated electricity in a time frame that is consistent with that required for exploration and resource evaluation on the Kilauea East Rift Zone. Based on industry statistics, exploration and resource evaluation may ~~be estimated to~~ take from one to three decades. This time frame is also consistent with projections of increasing demand for alternative energy supplies arising from an increase in constant dollar costs of fossil fuels anticipated to begin in about 1995.

248. Development of geothermal resources would provide numerous although ~~but~~ temporary job opportunities during the construction, maintenance, and operation of the roads, wells, and power generation facilities. The total number of temporary and permanent employment opportunities will depend on specific development proposals.

249. ~~Based on the assumption of~~ Assuming 25 project employees, direct wages may ~~be about~~ total $560,000 annually~~, having~~ with a multiplier effect totalling an estimated $1.3 million. This would cause some changes in the state and county economy, but would not result in a significant

impact. A greater potential for permanent jobs for local residents may be provided by direct use applications of geothermal heat.

250. Various sources of public revenue may result from a geothermal facility, including property tax, fuel tax, general excise tax, corporate income tax, personal income tax, and possibly royalty income.

251. Direct uses of geothermal heat should offer local residents many economic opportunities. The warm water effluent from a geothermal electric facility can provide an inexpensive source of process heat for various uses.

252. Some agricultural activities which can be supported by geothermal heat include: sugarcane processing, drying and dehydration of fruits and fish, fruit and juice canning, production of livestock feed from fodder, freeze drying of food and coffee, aquaculture and fishmeal production, refrigeration and ice making, soil sterilization, and fruit sterilization by dipping in hot water.

253. Industrial applications of direct use from geothermal energy may include extraction of potentially marketable minerals, such as silica or sulfur from geothermal fluids, production of cement building slabs, and production of liquid combustion fuels from biomass, e.g. bagasse or other agricultural by-products.

254. Other direct uses include hot geothermal mineral water spas which have proven to be of major commercial value in producing tourist revenue in Japan, Europe, U.S.S.R., and mainland United States, where millions visit these facilities annually. In places where fresh water is scarce, geothermal heat can be used to distill fresh water from saline water.

255. If the benefits of direct use applications are to be available in several areas, then small decentralized geothermal

facilities should be encouraged. Decentralized developments owned and operated by various developers may also promote competitive pricing for both electricity and process heat. With imaginative marketing, Big Island processed farm products can be sold world-wide.

256. The BLNR finds that there are significant economic benefits to be derived by electrical and direct use of geothermal resources.

G. Compatibility of Geothermal Development and Potential Related Industries with Uses Permitted Under Sections 183-41 and 205-2, Hawaii Revised Statutes, where the Area falls within a Conservation District

257. Section 183-41 of the Hawaii Revised Statutes establishes forest and water resource zones and delegates to the Department of Land and Natural Resources the responsibility for establishing subzones within the forest and water reserve zones.

258. Section 205-2 establishes four major land use districts in which all land in the state shall be placed: urban, rural, agricultural and conservation.

259. In the establishment of "conservation districts", the forest and water reserve zones provided in Section 183-41 were renamed "Conservation District". The boundaries of the forest and water reserve zones thereby became the boundaries of the Conservation District.

260. Section 183-41, HRS, has been implemented through Title 13, Chapter 2, Administrative Rules of the Department of Land and Natural Resources. Title 13, Chapter 2 establishes five (5) subzones within the Conservation District--Protective, Limited, Resource and General and Special Subzones where required.

261. The objective of the Protective Subzone is protection of valuable resources in designated areas such as restricted watersheds; marine, plant and wildlife sanctuaries; significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas.

262. Limited Subzones are designated areas where natural conditions suggest constraints on human activities.

263. The objective of the Resource Subzone is to develop with proper management, areas to ensure use of the natural resources of those areas.

264. General Subzones are open space areas where specific conservation uses may not be defined, but where urban use would be premature.

265. Special Subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area.

266. Most of the land within the proposed Kilauea Middle East Rift GRS is zoned Conservation, Protective Subzone. Only the extreme eastern and southeastern areas are zoned Agricultural.

267. Act 296, SLH 1983, as amended by Act 151, SLH 1984, specifically states that "geothermal resource subzones may be designated within urban, rural, agricultural and conservation land use districts established under Section 205-2, HRS.

The designation of conservation land for a geothermal resource subzone

268. ~~Subzoning of land designated Conservation~~ does not automatically permit geothermal development or convey any rights to individuals ~~beyond~~ a GRS designation [illegible] application for the required permits to conduct geothermal activities ~~within the area designated as a GRS.~~ many be considered

[illegible] the ground

269. In granting a Conservation District Use Permit (CDUA No. HA 3/2/82-1463) for geothermal exploration, the BLNR stated that "the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation lands involve multiple uses which range from absolute preservation to regulated uses...The range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restricted context." ~~This balancing test may also be applied by the BLNR to conservation lands contained within the proposed Kilauea Middle East Rift GRS when~~ subsequent ~~permits are considered.~~

270. The BLNR finds that controls can be implemented to mitigate potential impacts within the conservation district to protect valuable resources within this proposed subzone.

H. Consideration of the Hawaii Coastal Zone Management Act (Chapter 205A, HRS) and the Hawaii State Planning Act (Chapter 226, HRS) where applicable

271. Chapter 205A, HRS, relating to Coastal Zone Management is not applicable to the designation of a geothermal resource subzone along the Kilauea Middle East Rift, Island of Hawaii.

272. Chapter 226, HRS, relating to the Hawaii State Planning Act and its more detailed Energy Functional Plan encourage energy self-sufficiency generally and the use and development of geothermal energy specifically.

273. The BLNR finds that the designation of the proposed Kilauea Middle East Rift GRS complies with the provisions of Chapter 226, HRS.

ENVIRONMENTAL IMPACT ANALYSIS
OF
POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-106

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
October 1984

GEORGE R. ARIYOSHI
Governor

PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which address each of the subzone designation factors. This report analyzes the major environmental impacts that may result from geothermal development. Impacts include risks to people and property as well as wildlife and plant life. The effect of various natural factors such as wind and rain are included. Land use compatibility and impact mitigation measures are also described.

Preparation of this report was coordinated by Sherrie Samuels, Planner, with the assistance and under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development (DOWALD), Department of Land and Natural Resources.

DOWALD staff members, engineers George Matsumoto, Thomas Nakama, and Neal Imada, and geologists Daniel Lum and Ed Sakoda, have made significant contributions throughout this report. Paul Haraguchi of Pacific Weather, Inc. prepared the section on meterology and Lee Hannah of the University of Hawaii Environmental Center prepared the section on flora and fauna.

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SUMMARY

This report addresses potential environmental impacts to flora and fauna, surface and ground water resources, ambient air quality, and ambient noise levels, historical and archaeological resources, and scenic and aesthetic values. The characteristics and effects of local and regional meteorology are also considered.

The compatibility of geothermal development with existing land uses and zoning is examined. Evaluation of each resource area provides the conclusion of the study.

Meteorology. Meteorology, in general, and winds, in particular, are very important in geothermal operations because of their effect on emissions and noise. While tradewinds are prevalent, both tradewind temperature inversions and ground temperature inversions affect the movement of air in and over geothermal resource areas.

Flora and Fauna. One of the more serious environmental impacts is the potential disruption of native forest ecosystems. Two indicators were used to assess impact--native habitat importance and forest quality. Native habitat importance was defined by the presence of endangered species since this factor correlates well with the value of an area to native fauna in general. The relative value of a native forest was assessed using a three-part categorization system based on the percent of canopy provided and the quality of native forest present, the assumption being that undisturbed closed canopy, native forest would be the most susceptible to disruption by geothermal development.

Of Hawaii's seven plant species which are formally listed as endangered, only one, Hawaiian vetch, was found in a geothermal resource area. The presence of an endangered species was used as an indicator of environmental sensitivity. Protection of other rare native plants, not listed as endangered, is to be undertaken on a case by case basis in siting geothermal facilities in the future.

Surface Waters. Environmental impacts to surface waters resulting from geothermal development are expected to be minimal. None of the geothermal resource areas contain perennial streams and geothermal fluids will be disposed of by reinjection.

Groundwater. Groundwater occurs as perched, dike and basal water in geothermal resource areas. Groundwater resources will not be effected since geothermal wells are drilled past groundwater aquifers and well casings are set and cemented through a competent subsurface formation below the basal water lens. All drilling, casing installation, maintenance and abandonment of geothermal wells and reinjection wells will be regulated and monitored to protect the groundwater aquifer.

Air Quality. The assessment of air quality impacts resulting from geothermal development required examination of ambient air quality along active rift zones, emissions from geothermal wells and power plants and the current level of geothermal emission abatement technology.

Geothermal developments in Hawaii will be required to have abatement systems that meet the proposed State Department of Health air quality standards. At present, the recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the non-condensable gases. Use of this system would enable facilities to comply with the proposed air quality standards that require 98% of the H_2S present to be removed.

It should be noted that due to the sulfur content of fuel oil, oil-fired power plants may emit at least ten times more sulfur dioxide per megawatt-hour than would a geothermal power plant. Therefore, replacement of oil-fired power plants with geothermal power plants may reduce the overall impact to the environment and air quality.

Historic and Archaeological Values. Geothermal development may potentially degrade remaining cultural and archaeological values by site clearing and facility construction. Literature searches, plotting of known sites and on-site archaeological reconnaissance surveys should be utilized to assess potential impacts; adjustment of facility siting to avoid archaeologically sensitive areas will mitigate potential impacts.

Noise. During the initial phases of geothermal development persons in the vicinity of a geothermal facility construction site will be exposed to noise levels varying from 40 to 120 decibels depending upon the distance from the site. High noise levels are produced by well drilling, production testing and well bleeding before connection to the generator. Use of accoustical baffling and rock mufflers will effectively muffle noise. Construction of rock muffler at the existing HGP-A well has reduced noise level to 44 decibels at the facility fence line.

Compliance with County of Hawaii noise guidelines will limit noise levels for geothermal activities to 45 decibels at night and 55 decibels during the day.

Scenic and Aesthetic Values. Most geothermal resource areas are located in remote, often heavily forested areas, however in some areas, development of geothermal facilities may result in visual intrusions depending on an observer's view point. Site clearing, temporary presence of drilling rigs, permanent power plant structures with 50-60 foot high cooling towers, fluid transmission lines, electrical transmission lines, and periodic steam plumes above the development site are possible sources of visual intrusions. Appropriate mitigation measures may help to minimize visual impacts, however, some impacts such as steam plumes will remain.

Land Use Zoning, Existing Land Uses and Land Use Compatibility. Act 296, in addressing the designation of geothermal resource subzones, requires assessment of each geothermal resource area by an examination of various factors including the compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under Section 205-2 Hawaii Revised Statues, relating to State Land Use Districts, Section 183-41, HRS, relating specifically to Conservation Districts, and all uses permitted under County general plans or land use policies.

Act 296 also allows geothermal resource subzones to be designated within any of the four state land use districts established under Section 205-2 of the Hawaii Revised Statutes. As such, geothermal facilities could be located adjacent to any of the land uses existing or permitted in the four state land use districts.

The State Land Use Districts found in each of the potential geothermal resource rift zones are:

<u>Kilauea East Rift Zone</u> - Conservation, agricultural, and urban districts.

<u>Kilauea Southwest Rift Zone</u> - Conservation, agricultural, and urban districts.

<u>Mauna Loa Southwest Rift Zone</u> - Conservation and agricultural districts.

<u>Mauna Loa Northeast Rift Zone</u> - Conservation and agricultural districts.

<u>Hualalai Northwest Rift Zone</u> - Conservation and agricultural districts.

<u>Haleakala Southwest Rift Zone</u> - Conservation and agricultural districts.

<u>Haleakala East Rift Zone</u> - Conservation, agricultural, urban, and rural districts.

Actual land uses in geothermal resource areas although characteristic of their respective zoning, may vary considerably. As noted above, most geothermal resource areas contain conservation zoned land that includes forest reserve, national and state parks, other forested areas, brush and grass lands, and barren lava flows. Often conservation zoned lands provide habitat for native and rare or endangered species as well as hunting area, and watershed lands.

Potential subzone areas zoned agricultural are used mostly for livestock grazing.

Rural areas are characterized by low density residential uses on one-half acre lots and are often intermixed with small farms.

Urban areas include residential and commercial uses.

Some negative aspects, such as visual intrusions, are expected in developing geothermal resources; however, proper mitigation of undesirable characteristics can achieve greater compatibility.

In each resource area, both positive and negative aspects and possible mitigation were considered in assessing land use compatibility.

Evaluation of Impacts in Potential Geothermal Resource Areas

Evaluation of impacts was accomplished by reviewing available information for each geothermal resource area. Information on local meteorology, surface and ground water, underground injection control areas, existing land use and zoning, flora and fauna, historic and archaeological sites was systematically mapped and each area evaluated in terms of anticipated environmental impact.

Lower Kilauea East Rift Zone:

Development of geothermal resources in the Lower East Rift Zone has been underway since 1973-74 with the issuing of geothermal resource mining leases for four areas, designated GRML R-1, R-2, R-3, and R-4. Development of additional sites in the Lower East Rift zone will not impact any essential endangered species habitat, but may impact existing communities in terms of noise and aesthetics. The provision of a buffer zone will help to mitigate such impacts. Air Quality will not be impacted, since it is expected that given current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

Upper Kilauea East Rift Zone:

Development of geothermal resources in the Kilauea Upper East Rift zone will be limited to areas outside the Hawaii Volcanoes National

Park. Air quality within surrounding areas will not be impacted given the current level of abatement technology.

Site development may impact endangered o'u habitat; however, as stated in the Kahau'ale'a Environment Impact Statement (June 1082), "the minimal removal of vegetation and trees within the Kahua'ale'a project area should not significantly threaten the O'u."

Kilauea Southwest Rift Zone:

Development of geothermal resources in portions of the Kilauea Southwest Rift Zone, outside the National Park, would probably result in minimal environmental impact.

Development proximity to the Pahala and Punaluu communities may result in aesthetic impacts, however, air quality will not be impacted.

Mauna Loa Northeast Rift Zone (Kulani):

Development of a geothermal resource in areas other than the cleared grazed agricultural area in this rift zone may impact the four endangered forest bird species and the Nene by disturbing essential habitat areas.

Mauna Loa Southwest Rift Zone (Kahuku Ranch):

Development of geothermal resources in the lower, agricultural-zoned portion of the proposed subzone may result in minimal environmental impact provided a buffer area is maintained between the geothermal development site and the Hawaiian Ocean View Estates.

Hualalai Northwest Rift Zone:

Development of geothermal resource in areas other than the grazed agricultural zoned portion of the subzone may impact the endangered species known to exist within the rift zone area. Alala, the Hawaiian Crow, is reported to number fewer than 20 individuals.

Disturbance of their Hualalai habitat may cause further decline of this species, or its extinction.

Haleakala Southwest Rift Zone:

Development of geothermal resources within the grazed agricultural zoned portions of the rift zone will result in minimal impact to fauna since no endangered species habitat is present.

Proximity to the Makena residential and resort development, Ulupalakua Ranch and upslope, the Haleakala "Science City" may be affected aesthetically. Air quality in urbanized areas will not be impacted since it is expected, given the current level of technology, that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal resource development.

Haleakala East Rift Zone:

Development of a geothermal resource in the Haleakala East Rift Zone in areas other than the grazed agricultural lands below the 1000-foot level may impact native forest bird habitat and above 4200 feet, endangered forest bird habitat. However, development of a geothermal resource below the 1000-foot level in grazed agricultural land could place a geothermal well and power plant as close as 7000 feet from the center of Hana Town. Quite clearly, the rural lifestyle of the Hana Community would be affected.

INTRODUCTION

Act 296, Session Laws of Hawaii 1983, requires that environmental impacts be considered when the Board of Land and Natural Resources designates subzone areas for the development of geothermal resources. This report addresses the major environmental impacts that are likely to result from geothermal development.

Environmental impacts are described generally; the effects of various natural factors such as wind and rain are included. Impacts include risks to people and property as well as to wildlife and plant life. Impact mitigation is also described and each resource area is evaluated.

METEOROLOGY: DESCRIPTION AND EFFECT

Climatological elements deemed important in assessing environmental impact in geothermal rift zones include rainfall, temperature, winds, trade wind inversions, and ground temperature inversions. Cloudiness, solar radiation, and relative radiation are not considered important elements in geothermal development and in Hawaii data for these factors are not available for areas within rift zones.

AIR TEMPERATURE

Air temperature decreases by approximately 3°F for each 1,000 feet rise in elevation in the Hawaiian Islands. This relationship is seen in Figure 1 where the heavy slanted line (towards the left or colder temperature) has a decrease in temperature of 3°F per 1,000 feet elevation rise. The horizontal lines represent the range of the average maximum and minimum temperatures at the different locations. For example, Haleakala Rangers Station at 7,030 feet elevation has a minimum temperature of 44°F and a maximum temperature of 63°F.

WINDS

The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise. The most common winds over the Hawaiian Islands are the trade winds from the east which account for about 70% of the winds in the Islands. Figures 2a and 2b show the mean pressure and wind flow of the Pacific Anticyclone in the Eastern and Central North Pacific for January and July, the months representing the opposite seasons for winter and summer. The mean charts show the dominance of the high and outflowing trades in the Eastern and Central North Pacific especially in the summer. The mean trade wind pattern is a smooth version of the actual happenings. At any given time, the wind flow is not as static as it appears in the mean charts because the high, the source of the trades, is not as static, especially in the winter.

Over the Hawaiian Islands, the trades prevail over 90% of the time from June through August and only 40 to 60% of the time from January through March. During summer, the trade winds can persist through an entire month while during winter trade winds are sometimes absent almost an entire month. The reason for the high frequency of the trade winds during the summer is that the Islands are in the belt of the almost persistent trade winds from the Pacific Anticyclone. During winter, the mean position of the high is further south of the summertime position and the high is not as strong or as persistent. Interruptions in the trades over the Islands are much more frequent in winter than summer with the intrusions of low pressure systems displacing the high pressure area from the Islands or the high pressure area moves far away from the Islands. These are the times that non-trade winds mainly in the form of light and variable winds or light southerly winds occur in the Islands.

Winds over the rift zones are explained with limited data. There are a few wind summaries in or near the rift zones which were used but the main source of the material for the wind discussion was the knowledge of the behavior of the trade winds and the theory of the sea breeze and mountain breeze (local upslope and downslope winds).

Earlier written articles by others were also utilized in the formulation of the wind patterns over the rift zones.

TRADE WIND TEMPERATURE INVERSION

A temperature inversion is a layer in the atmosphere in which the air warms with increase in altitude which is the inverse of the normal temperature decrease through the atmosphere. Figure 3a shows an example of the vertical air temperature profile with a temperature inversion at 6,000 feet altitude.

The trade wind temperature inversion occurs about 70% of the time over the Hawaiian Islands caused by the sinking of the air at the level of the inversion from the high pressure area north of the Islands. The trade wind temperature inversion is generally persistent in space and time when it occurs. Its mean height above sea level is between 6,000 and 8,000 feet. Normally, it ranges in height between 5,000 and 9,000 feet. It occurs more often during the summer months than during the winter months. Its strength as measured by the temperature increase in the layer of the inversion from its base to its top, varies from no temperature increase through the layer to an increase of several degrees (°F) through the layer. The trade wind temperature inversion can be measured twice a day (2:00 am and 2:00 pm) in the radiosonde data at Hilo and Lihue Airports by the National Weather Service.

GROUND TEMPERATURE INVERSION

The cooler drainage air from the mountain tops flowing down the slopes and the radiational cooling of the ground at night can produce temperature inversion over some of the rift zones (Fig. 3b). The strength of this inversion in temperature is probably only a few degrees (°F) increase in temperature through a shallow layer of a few hundred feet. The inversion will break down by the heating of the land by the sun in the morning. The important conditions for the formation of the ground temperature inversion are:

1. clear night and few or no low cloud cover

2. low or no winds
3. stable atmosphere
4. cool air draining down from the higher slopes

The conditions that are against the formation of the ground temperature inversion are:

1. overcast low clouds
2. windy conditions
3. unstable atmospheric conditions, rain
4. no drainage wind flow

FLORA AND FAUNA

One of the most serious potential impacts of geothermal energy development in Hawaii is the disruption of native forest. Air pollution and groundwater impacts of geothermal development may be substantially avoided by requiring full control technologies; impact on native forest ecosystems can be mitigated through careful siting (EPA, 1978). Siting to avoid damage to biologically valuable forest can prevent both degradation of the forest due to invasion of weed species and disturbance of native bird species due to human activity and noise.

Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas (Carlquist, 1970). Once such as invasion begins, native forest is gradually altered, and non-native species, which initially invaded along relatively narrow corridors, spread and multiply (Corn, 1984). Major geothermal development, with an attendant network of roads and construction corridors, may be expected to dissect and eventually degrade undisturbed native forest by opening it to invasions by weedy species.

Geothermal development may also be expected to have negative impact on native forest birds, including many which are endangered. Construction noise and human activity are factors which favor urban nuisance species over native forest species (Berger, 1972). It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal energy development. Any development within the habitat of native birds will have potential environmental impact and should be fully investigated and mitigation measures implemented.

In selecting areas in which geothermal development will have the least environmental impact, it is therefore useful to assess both forest quality and native bird habitat. Those areas with mature native forest and significant native bird habitat will tend to be the most environmentally important, while those without native bird habitat and with less intact forest will be substantially less impacted. For this study, two indicators were used to distinguish, on a broad scale, areas of high and low potential environmental impact. The indicators chosen were native habitat importance and forest quality.

The indicator chosen to depict the value of an area to native fauna is the presence of endangered species. While under some circumstances a simple survey for endangered species is an unacceptably superficial form of environmental assessment, in the present situation the presence of endangered species correlates quite well with the value of the area to native fauna in general. Relative value of native forest has been assessed using a categorization system developed by the University of Hawaii Environmental Center based on forest type mapping done by the United States Fish and Wildlife Services (Jacobi, 1983). This system indicates areas in which geothermal development would have the greatest environmental impact, areas in which geothermal development would have little or no impact on valuable native forest, and areas in which the impact of geothermal development on native forest is uncertain. Map overlays were prepared to illustrate the distribution and intersection of essential habitat and forest quality factors.

Endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are plans of action for restoring the population of a species pursuant to its listing as endangered by the Secretary of the Interior. Recovery plans are drafted by teams of wildlife experts from both state and federal agencies, and represent estimates of the range and life requirements of endangered species by the foremost experts in the field. Essential habitat outlined in an Endangered Species Recovery Plan is therefore almost without exception the most authoritative estimate of the actual habitat for a particular endangered species. Where no essential habitat has been designated, distribution was determined from population surveys conducted by the U.S. Fish and Wildlife Service or other available information (Scott, 1984). Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow (Alala) on the island of Hawaii and for the Nene on both Maui and the Big Island. Essential habitat has not been determined for the endangered Maui forest birds, and therefore U.S. Fish and Wildlife Service population counts were used to determine habitat boundaries for these species.

The potential for environmental impact on the flora of the resource areas was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping. The U.S. Fish and Wildlife Service system incorporates information on extent of canopy cover, height of canopy, understory composition, and vegetation association type (Jacobi, 1983). Vegetation information has been assembled and mapped by the Service using this system for large portions of four of the five main Hawaiian islands, including Maui and Hawaii. Information in this form was available for all or portions of each of the resource areas. Areas not covered were lower Hana, lower Makena, Kilauea S.W. Rift, and Lower Puna. In these areas aerial photo interpretation was used to estimate vegetation type, and in high resource potential areas this aerial interpretation was verified on the ground from readily accessible roadways wherever possible. Lack of access routes made ground verification for the Kilauea S.W. Rift site impractical. The boundaries delineated on the aerial photographs were transferred to orthophoto quadrangles and assigned a vegetation type code following the USFWS system (Jacobi, 1983). Vegetation type data was then ranked according to potential for impact from geothermal development into one of three categories described below.

FLORA

Vegetation type data from U.S. Fish and Wildlife Service mapping or the present study were abstracted into a simplified, three category impact sensitivity classification system (see appendix A). The three categories of this system, which was developed by the University of Hawaii Environmental Center, and based on the assumption that undisturbed, closed canopy forest would be most susceptible to disruption due to geothermal development, are as follows:

CATEGORY 1 - Exceptional native forest;
closed canopy, over 90% native cover

CATEGORY 2 - Mature native forest;
over 75% native canopy

CATEGORY 2A - Native scrub or low forest

CATEGORY 3 - Cleared land; non-native forest;
bare ground or lava

In this system, Category 1 forests are presumed to be areas in which geothermal development would unquestionably result in environmental impact, and Category 3 lands presumed to be areas in which geothermal development would have little or no impact. Category 1 forest is vulnerable because of its high native composition, which indicates that it is virtually undisturbed, and because of its closed canopy, which indicates that any development activity would result in changes in forest structure. Category 3 lands are assumed to be of little biological value owing to high degrees of disturbance or low percentage of ground cover. Category 2 is comprised of areas which did not meet the rigorous standards of Category 1, but are not so heavily disturbed or sparsely vegetated that it can be assumed that development would not result in environmental impact. Category 2A represents areas in which the vegetation is predominantly native, but the tree layer is low and scattered and does not warrant the designation of forest. In wet forests, Category 2A vegetation is a sign of disturbance, but in dry regimes, particularly at altitude or along the coast, it is a healthy native ecotype. Both Category 2 and 2A are then classifications which convey that additional information is needed before it can be assumed that geothermal development would have little environmental impact.

The additional information needed to assess the biologic value of Category 2 forest pertains to forest diversity and the presence of rare plants. These factors were not included in the present assessment because this information is not available in any comprehensive form on such a broad scale. Information on species diversity is similarly unavailable in any readily accessible form. Because of these limitations of information availability, it is difficult to arrive at an objective classification for potential for impact by geothermal development for many forest types. There are unquestionably many excellent forest areas that have been placed in Category 2 because they fell just short of 90% native composition. There are equally certainly areas assigned Category 2 which are of little biological interest. Within these extremes, the majority of Category 2 forests are areas for which the USFWS vegetation type code tells only a part of the story, and diversity and rare plant information is required to discern the exact value and vulnerability to disturbance of the area. In the absence of a compelling reason to develop these areas, a reasonable assumption is that they are valuable and should not be disturbed. Where there is compelling reason to consider development, field reconnaissance of individual areas will be required to determine what, if any, level of environmental impact would result from development. Similar considerations apply to Category 2A areas. Vegetation types are assigned to Category 2A based on growth form, not biological value or environmental impact considerations. However, it may be worthwhile to emphasize that in wet areas at intermediate elevations, Category 2A usually represents a disturbed area or recent lava flow.

In summary, Category 1 areas are those in which substantial environmental impact can be expected to result from geothermal development, Category 2 and 2A areas are those in which geothermal development should be assumed to result in environmental impact in the absence of additional information, and Category 3 areas are those in which geothermal development may be expected to have little or no environmental impact.

Clearly the environmental advantage lies in developing within Category 3 areas. It is also worthwhile to note that environmental impact, especially on native forest birds, may result from development immediately adjacent to Category 2 areas or endangered species habitat, even if the site is Category 3, if it is in close enough proximity for noise or pollution to carry to the forest. In these instances, buffer zones can be utilized to mitigate any impact which may occur.

Rare Plants

Of Hawaii's seven plant species which are formally listed as endangered, only one, the Hawaiian vetch (*Vicia menziesii*) is found within the resource areas (see Figure 4). However, Hawaii has numerous rare plants, over 800 of which have been proposed for listing as endangered. Undoubtedly many of these candidate species may be found within the resource areas. For example, the endemic Hawaiian fern, *Adenophorus periens*, is known to be present in the Kahauale'a section of the Kilauea East Rift Zone.

Currently available information on rare species does not permit a comprehensive inventory of these species and their location, and therefore has not been addressed in this study. Protection of rare plant species will have to be undertaken on a project-by-project basis, where botanical surveys of specific areas being considered for development are possible. The forest categories presented in this study do not relate to endangered plant species presence. It should not be assumed that Category 3 areas will contain no rare plant individuals. Isolated rare native species are not uncommonly found in disturbed, non-native surroundings. Such individuals should be identified and protected, but the scope of the present study precluded such detailed analysis. Areas with high concentrations of rare plants are biologically valuable, and the presence of rare plants is one criteria which should be used in determining the potential impact of geothermal development in Category 2 areas. For example, the

Category 2 forests in the southwest quarter of the Mauna Loa East Rift area are the home range of Vicia menziesii and should therefore be considered very sensitive to environmental impacts, despite the fact that the forest type alone does not warrant ranking them in Category 1. Other areas such as this definitely exist within Category 2, and this is one reason why it is important to more completely characterize these areas before their sensitivity to impact is assigned.

FAUNA

Forest birds found in the resource areas include the I'iwi, Apapane, Elepaio, and others. The specific native forest birds present at a site are not as important as the relative value of the area as native bird habitat in general. Most native birds share habitat to some degree, and it is this characteristic which permits use of the existence of endangered bird habitat as an index of overall native bird habitat value. Because the list of native birds in the resource areas is long, discussion here will focus only on the endangered fauna found in the resource areas.

Federally designated threatened or endangered fauna within the resource areas include seven forest bird species, two seabird species, the Nene, the Hawaiian Hawk (Io) and Crow (Alala), and Hawaii's only resident mammal, the Hawaiian Hoary Bat. These species and their treatment in the resource area overlays are outlined below.

'Alala (Corvus tropicus) - One of the most critically endangered species in the United States. Population estimate 10-50 birds in the wild. Last field census reported 7 birds. Essential habitat identified, intersects majority of Hualalai resource area and flanks Kahuku Ranch resource areas (DLNR, 1984).

Hawaii Forest Birds - Includes the Hawaii Creeper (Loxops maculatus mana), Hawaii 'Akepa (Loxops coccineus coccineus), Akiapola'au (Hemignathus wilsoni), and 'O'u (Psittirostra psittacea). All are moderately endangered, with populations in the high 100's or above, except the 'O'u, which is relatively rare and has a much smaller population. Essential habitat common to all four species has been identified, and intersects all of the East Mauna Loa Rift area, most of Hualalai and Upper Puna, and flanks Kahuku Ranch (USFWS, 1982).

Maui Forest Birds - Includes Crested Honeycreeper (Palmeria dolei), Maui 'Akepa (Loxops coccineus), Maui Parrotbill (Pseudonestor xanthophrys). Essential habitat not yet identified. Distribution determined by USFWS, intersects upper Hana (Scott, 1984).

Nene (Branta sandwicensis) - Moderately endangered, maintained by captive breeding. Essential habitat identified, intersects all of East Mauna Loa Rift, most of Hualalai, and the upper elevations of Kahuku Ranch (USFWS, 1983). An upland bird adapted to sparse vegetation the Nene may be less sensitive to the presence of geothermal development than other native birds.

Hawaiian Hawk (Buteo solitarius) - Relatively common over a wide range. No essential habitat established. Known nesting sites established by USFWS lie mainly in Lower Puna and East Mauna Loa Rift, but nesting observations are far from exhaustive and lie mainly along roadways and other accessible areas (Griffin, 1984).

Hawaiian Dark-Rumped Petrel (Pterodroma phaeopygia sandwichensis) - Primary nesting colonies on Maui, outside of resource areas. Also observed within Napau Crater in Volcanoes National Park (USFWS, 1983).

Hawaiian Hoary Bat (Lasiurus cinereus semotus) - A poorly characterized species (Kepler and Scott, 1980). No know roosting sites within resource areas. Most frequently observed in non-native vegetation. Impact of development on foraging habitat uncertain, possibly minimal.

Newell's Manx Shearwater (Puffinu puffinus newelli) - Classified as threatened. No known nesting colonies within resource areas. May occasion Upper Puna and East Mauna Loa Rift (Jacobi, 1984). Impact of development uncertain, may be minimal.

Figure 5 provides sketches for reference for the species named above.

Invertebrates

Rare invertebrates known to exist in the resource areas include scientifically important fruit flies (giant Drosophila spp), tree snails (Partulina spp), and special care-adapted fauna residing in lava tubes. The giant Drosophila species, focal point of important genetic research, are found in the Mauna Loa East Rift and Hualalai areas, and at upper elevations at Hana and Kahuku Ranch (Carson, 1984). Tree and land snails, many of which, like other Hawaiian invertebrates, are found nowhere else in the world, are associated primarily with native forest and probably exist in all resource areas.

Cave-adapted fauna might be found in lava tubes underlying any resource area, but are known to exist in Mauna Loa East Rift and Kilauea East Rift. These lava tube ecosystems are dependent on intact penetrating ohia root systems for their moisture supply, and are vulnerable to any development which results in forest clearing. While invertebrate species often receive less attention than vertebrate fauna, they comprise an important part of native ecosystems. Impacts on these species may be largely avoided by avoiding siting in native forest areas.

SURFACE WATER IMPACT

Geothermal development activities should not directly affect existing land uses since there are no surface streams located in the recommended areas. While drilling and construction phases of geothermal development may be a cause of concern, little or no environmental impacts are expected. However, if surface water becomes available, accidental pollution of streams should be prevented by use of adequate and safe disposal methods of geothermal brine.

Following initial development of the geothermal resources, the production of potentially valuable associated geothermal products--demineralized water and mineral salts--could have beneficial environmental consequences. From a resource point of view, their development is desirable and should be considered. However, then recovery and production of byproduct mineral salts from geothermal brines is not economically feasible, adequate and safe disposal by reinjection will be utilized.

Almost all geothermal fluids have a total dissolved solids content greater than 1000 ppm, and their indiscriminate discharge into streams, ponds, and watersheds should not be allowed. The normal disposal practice is expected to be by reinjection. In some cases it is possible that byproduct fluids may be of satisfactory quality to be disposed of without treatment. Surface disposal, in these case, could be allowed under controlled conditions.

Environmental impacts on surface waters resulting from the development of geothermal resources in the prospective geothermal subzones are expected to be minimal. None of the subzones under consideration contains perennial streams. One, the Haleakala East Rift Zone in Maui, contains a small intermittent stream and the headwaters of several other intermittent streams that exit the subzone at their upper reaches.

GROUNDWATER HYDROLOGY

Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water.

Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations (Figure 6).

Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes water is held between the dikes to a height of more than 2,000 feet above sea level.

Basal water occurs most commonly in the islands. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. In the areas considered, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the groundwater aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions, and alternate safe disposal methods should be developed.

KILAUEA EAST RIFT ZONE

Ground water occurs as dike water and basal water in the Kilauea East Rift Zone. The only known perched water exists north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic gradients along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone on ground water movement. The effectiveness of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels (Figure 7).

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 19,000 mg/l. Because of the effects of mixing, most ground water at the coast is brackish. Salinity and temperature vary greatly north and south of the rift zone. Wells and shafts north of the rift zone are characterized by lower temperatures and lower salinities. Wells in and near Keaau have water temperatures of 66° to 68°F. The water temperature of wells near Pahoa ranges between 72° and 74°F. Wells located more than 3 miles inland generally have a chloride concentration of less than 20 mg/l. South of the rift zone, high well-water temperatures and salinities are encountered. The water temperature of the Malama-Ki well, 2783-01, in 1962 was 127°-130°F with salinity between 5500 and 7000 mg/l at pumping rates of 100 to 480 gpm. The water temperature of thermal test well No. 3 in 1974 was 199°F, with salinity of 2000 mg/l. The average chloride content of ground water south of the rift zone is probably greater than 300 mg/l, probably due in part to heating of sea water by volcanic activity below the basal lens. The warmer, less dense sea water rises, contaminating the fresh water in the basal aquifer.

OTHER POTENTIAL SUBZONES

Ground water occurrences in the other potential subzones are similar to that found in the Kilauea East Rift Zone. Basal water underlies the areas except where the dikes of the rift zones occur. Isolated occurrences of perched water may be found but it would be of little significance. Water levels would vary according to the amount of rainfall in the area and the barrier effect of the rift zones. Water temperature and salinity in the rift zones would vary with the amount of residual heat from past volcanic activity. The greater the amount of heat present, the greater the temperature and salinity of the ground water.

AIR QUALITY

Assessment of air quality impacts resulting from geothermal development requires examination of ambient air quality in geothermal rift zones, emissions from geothermal wells and power plants, and the current level of geothermal emission abatement technology. Ambient air quality and potential environmental impacts from emissions are discussed in this report, geothermal development emissions and abatement techonology are discussed in a seperate report entitled Geothermal Technology, Circular C-108.

Environmental risks are due primarily to atmospheric emissions of noncondensing gases from the development and operation of geothermal wells and power plants. Hydrogen sulfide, and particulate sulfate from the atmospheric oxidation of hydrogen sulfide, benzene, mercury and radon are considered to be the more significant noncondensing gases from a health standpoint (Layton, 1981).

In addition, disposal of geothermal fluids can also pose a health risk if the disposal contaminates surface waters or, if injected, ground waters. The presence of arsenic in geothermal fluids is also a consideration.

The chemical composition of gases varies with the location of the geothermal reservior; however, the major constituent is typically carbon dioxide, and significant amounts of methane and hydrogen sulfide with trace amounts of benzene, radon and mercury. It should be noted that gases from igneous-related geothermal resources such as Kilauea East Rift Zone typically have much lower quantities of benzene or none at all.

Exposure to atmospheric concentrations of hydrogen sulfide, benzene, radon, and mercury poses potential hazards to public and occupational health. In addition, exposure to hydrogen sulfide and toxic chemicals contained in abatement systems also poses an occupational health hazard. (Layton, 1981).

HYDROGEN SULFIDE

Hydrogen sulfide is found in nearly all high temperature geothermal fluids. It also occurs naturally in coal, natural gas, sulfide springs and lakes and is a product of anaerobic decomposition of sulfur containing organic matter.

Production of hydrogen sulfide from volcanic gases is the result of the action of steam on inorganic sulfides at high temperatures. The same reaction is responsible for the production of the gas in steam from geothermal wells.

Hydrogen sulfide is a colorless gas which has a characteristic obnoxious odor of rotten eggs even at low concentrations (the odor threshold is in the micrograms per cubic meter). At higher concentrations the gas is toxic to human and animals and is corrosive to many metals (National Research Council, 1979). In humans at low concentrations it causes headache, conjuctivitis, sleeplessness, pain in the eyes, and similar symptoms. At high concentrations the gas can paralyze the olfactory nerve and at higher concentrations, result in rapid death. The following table identifies the range of effects at various concentrations.

Because hydrogen sulfide is rapidly oxidized in the blood to harmless and easily elimanted sulfates, it is considered a noncumulative poison. There is no evidence to indicate hydrogen sulfide is carcinogenic, mutagenic or teratogenic (Layton, 1981).

Plant species differ widely in their response to hydrogen sulfide, and in their response to different concentrations of the gas. Long-term exposure to hydrogen sulfide results in damage to plants at concentrations between 0.042 mg/liter (0.03 ppm) and 0.42 mg/liter (0.03 ppm). However at 0.03 ppm some species exhibit growth stimulation, but at 0.3 ppm these species show damage (National Research Council, 1979).

Table 1 summarizes hydrogen sulfide concentrations in the ambient air in the Kilauea East Rift Zone. Various standards, worldwide means and biological impact values are indicated.

The authors of the Environmental Baseline Survey at the Kilauea East Rift concluded in their first year report that current hydrogen sulfide levels in the Kilauea East Rift Zone are very low, and well below biological impact values. Occasional short-term H_2S episodes were observed during the baseline survey at two sites (Site 4, and Volcano Village, see Figure 8) but were of short, less-than-a-day duration and only at modest concentration levels.

SULFUR DIOXIDE AND ACID RAIN

Hydrogen sulfide, released from geothermal facilities will oxidize in the atmosphere to sulfur dioxide, which is then oxidized to sulfate aerosols (Layton, 1981). Sulfur dioxide is injurious to human health and the environment and is the princpal precursor of acid rain.

Studies dealing with acute inhalation of sulfur oxides generally indicate that health effects are unlikely at the ambient levels expected to occur as a result of atmospheric oxidation of hydrogen sulfide.

Table 1. Comparison of Hydrogen Sulfide Concentrations with Standards, Worldwide Means, and Biological Impact Values

Parameter	Concentration ($\mu g/m^3$)
Site 2, multi-day[1] integrated samples	< 0.07 - 0.7
Site 4, multi-day[1] integrated samples	< 0.06 - 1.8
Remote Site A, multi-day[1] integrated samples	< 0.06 - 0.8
Remote Site B, multi-day[1] integrated samples	< 0.1 - 1.2
Remote Site D, multi-day[1] integrated samples	< 0.06 - 0.5
Site 2, 15 min. avg.[2]	< 0.8 - 2.0
Site 4, 15 min. avg.[3]	< 0.8 - 11
Volcano Village, real time values[4]	< 1.5 - 10.1
Colortec Card Network[5] multi-day integrated values	< = 10
Ambient Air Quality Stds.	
1 hr., California	152
New York	152
1 time, U.S.S.R.	9.1
24 hrs., U.S.S.R.	9.1
TLV[6]	15,000
Typical Atmospheric Background	0.3
Miami, Florida, Polluted Air[7]	0.17 - 1.15
North Carolina, Polluted Marsh[7]	80
United States[7]	0.15 - 0.45
Panama[7]	0 - 1.0
Colorado[7]	0.04
Illinois & Missouri[7]	0.12 - 0.3
Miami, Florida[7]	0.008 - 0.08
West Germany[7]	0.035 - 1.65
Island of Sylt (North Sea)[7]	0.1
Ivory Coast[7]	0.1 - 8.7
France[7]	0.017 - 0.17
Above Polluted Air, New Zealand[7]	1,000
Polluted Air, U.S.A.[7]	1,000

Source: Houck, Vol. 1, 1984.

Table 1. (Continued)

Parameter	Concentration (μg/m³)
No injury to 29 plant species, fumigated for 5 hrs.	60,000
No damage to Boston Fern, apple, cherry, peach and Coleus, fumigated for 5 hrs.	600,000
Moderate damage to gladiolus, rose, castor bean, sunflower and buckwheat, fumigated for 5 hrs.	60,000 to 600,000
Odor threshold. No reported injury to health	1 - 45
Threshold of reflex effect on eye sensitivity to light	10
Smell slightly perceptible	150
Smell definitely perceptible	500
Minimum concentration causing eye irritation	15,000
Maximum allowable occupational exposure for 8 hours (ACGIH Tolerance Limit)	30,000
Strongly perceptible but not intolerable smell. Minimum concentration causing lung irritation	30,000 - 60,000
Olfactory fatigue in 2-15 minutes; irritation of eyes and respiratory tract after 1 hour; death in 8 to 48 hrs.	150,000
No serious damage for 1 hour but intense local irritation; eye irritation in 6 to 8 minutes	270,000 - 480,000
Dangerous concentration after 30 minutes or less	640,000 - 1,120,000
Fatal in 30 minutes	900,000
Rapid unconsciousness, respiration arrest, and death, possibly without odor sensation	1,160,000 - 1,370,000
Immediate unconsciousness and rapid death	1,500,000+

[1] 1/25/83 - 12/10/83

[2] 5/28/83 - 9/1/83

[3] 12/18/82 - 5/26/83

[4] 9/12/83 - 11/8/83

[5] 12/14/82 - 12/12/83

[6] American Industrial Hygiene Assoc., Maximum Recommendations for Exposure, 8 hrs/day, 5 days/week

[7] Source: Aneja, V.P., et al., Biogenic Sulfur Compounds and the Global Sulfur Cycle, J. Air Poll. Control Assoc., 1982, v. 32, pp. 803-807.

Source of other comparison values: Chemical Rubber Co., Handbook of Environmental Control, Volume 1, Air Pollution, 1972, and U.S. Dept. of Health, Education and Welfare, Preliminary Air Pollution Survey of Hydrogen Sulfide, 1969.

Source: Houck, Vol. 1, 1984

Other epidemiological studies suggest that the inhalation of particulate sulfates rather than sulfur dioxide is a primary source of risk associated with long-term, low-level exposure to polluted air. Sulfate aerosols are respiratory irritants, and are used to measure the health hazard of exposure to polluted atmospheres containing sulfur oxides and particles.

Acid rain usually originates with emissions of sulfur dioxide-SO_2, which can oxidize to SO_3, and eventually forms H_2SO_4-sulfuric acid, which falls as acid rain. Three potential sources of acid rain are: (1) natural volcanic emissions, (2) geothermal emissions, and (3) emissions from oil-fired power plants.

In the absence of a volcanic activity, sulfur dioxide values are low. However, during an eruption concentrations, due to volcanic activity, can exceed human health and plant impact values for days at a time.

Rainwater in the Puna and Ka'u districts in the vicinity of the Kilauea Rift Zone, is slightly acidic due to not only acidification from local volcanic sources of sulfur dioxide but also from long-range transport of pollutants across the Pacific.

At present, it is notable that no detectable amount of sulfur dioxide is emitted from the Puna HGP-A facility noncondensed gas stream. Hawaiian geothermal developments are expected to have abatement systems which can abate hydrogen sulfide emissions by about 99%, which should meet proposed state Department of Health air quality standards for geothermal development of 98% H_2S abatement during goethermal power plant operation in addition to an incremental standard.

It is expected that the remaining unabated 1% H_2S would take several days to become acidic and by that time, prevailing winds should take any pollutant remaining out to sea.

It should be noted that due to the sulfur content of fuel oil, oil-fired power plants may emit about 100 times more sulfur dioxide per megawatt-hour than would a geothermal power plant (Thomas, 1984). As such, replacement of oil-fired power plants capacity with geothermal plants may actually reduce the potential for acid rain. Thus, acid rain resulting from geothermal sources should not significantly effect nearby land areas.

Table 2 summarizes sulfur dioxide concentrations in the ambient air in the Kilauea East Rift Zone. Various standards, worldwide means, and biological impact levels are also indicated for comparison.

BENZENE

Benzene is associated with the gas phase of fluids derived from geothermal reservoirs of sedimentary origin. Igneous-related geothermal systems, such as Kilauea exhibit smaller levels of benzene or none at all because such systems contain less organic matter. (Layton, 1981).

Benzene is a hematotoxin that can cause various blood disorders. Epidemiological studies of workers exposed to benzene provide strong evidence that the chronic inhalation of benzene can lead to leukemia.

MERCURY

The health effects of long-term exposure to airborne elemental mercury have been studied less than the effects from ingestion of foods contaminated with the methylated form of mercury. However, epidemiological studies indicate that persons exposed to mercury vapor in the work environment have shown mercury intoxication resulting in muscle tremors, psychosomatic disturbances, deterioration of intelligence, inflammation of the oral cavity and lens discoloration (eye). Mercury emissions from geothermal facilities are not likely to cause acute health effects; however, prolonged exposure to atmospheric mercury may cause subtle effects such as psychosomatic disturbances and finger tremors. (Layton, 1981).

Elemental mercury vapor was measured in the Baseline Survey for the Kilauea East Rift Zone, and an increase in the particulate mercury content of samples during the January 1983 Kilauea eruption was noted. Table 3 from the Baseline Survey, Volume 1, provides a comparison of elemental mercury vapor and particulate mercury concentration in the Kilauea East Rift zone. Comparison with

Table 2. Comparison of Sulfur Dioxide Concentrations with Standards, Nationwide Means, and Biological Impact Values

Parameter	Concentration ($\mu g/m^3$)
Site 2, multi-day[1] integrated samples	< 0.06 - 8.7
Site 4, multi-day[1] integrated samples	< 0.06 - 43
Remote Site A, multi-day[1] integrated samples	< 0.06 - 28
Remote Site B, multi-day[1] integrated samples	0.14 - 39
Remote Site D, multi-day[1] integrated samples	< 0.05 - 31
Site 2, 15 min, avg.[2]	< 1.4 - 3.4
Site 4, 15 min, avg.[3]	< 1.4 - > 286, > 983[4]
Volcano Village, real time values[5]	< 4.0 - > 1964
Ambient Air Quality Stds.	
24 hr., Primary U.S.	365
Annual mean, Primary U.S.	80
24 hr., Hawaii	80
Annual mean, Hawaii	20
1 hr., California	2,857
8 hr., California	857
1 hr., New York	714
24 hr., New York	286
1 time, U.S.S.R.	1,543
24 hr., U.S.S.R.	171
TLV[6]	13,000
Typical Atmospheric Background	0.6
Yearly Avg. SO_2 (1968)	
Chicago	343
Cincinnati	57
Philadelphia	229
Denver	29
St. Louis	86
Washington, D.C.	114
Maximum 24 hr. avg. (1968)	
Chicago	1,457
Cincinnati	229
Philadelphia	1,029
Denver	143
St. Louis	457
Washington, D.C.	514
Plant Leaf Symptoms, 24 hr. exposure	800
Plant Chlorosis, single exposure	> 714
Plant Chlorosis, annual avg.	86
Plant Growth Altered	143 - 571
Odor	1,428 - 2,000
Taste	286 - 857
Epidemological Significance (24 hr., annual avg.)	43
Pulmonary Function, 10 min. exposure	4,571
Discomfort	14,285
Severe Distress, 10 min. exposure	14,285 - 28,570

Source: Houk 1984

1 1/25/83 - 12/10/83

2 5/28/83 - 9/1/83

3 12/18/82 - 5/26/83

4 The maximum dynamic range of the continuous H_2S/SO_2 monitor is 100 ppb (286 $\mu g/m^3$) due to its design for sensitive low-level background work. During the first phases of the Kilauea eruptions, this value was exceeded frequently. The State of Hawaii Dept. of Health reported on 1/8/83 a 24 hr. mean of 983 $\mu g/m^3$. This monitor was less than one kilometer from Site 4, hence 15 min. values greatly in excess of 983 $\mu g/m^3$ unquestionably occurred at Site 4.

5 11/8/83 - 12/31/83

6 American Industrial Hygiene Assoc., Maximum Recommendation for Exposure, 8 hrs/day, 5 days/week

Source of Comparison Data: Chemical Rubber Co., Handbook of Environmental Control, Volume 1, Air Pollution, 1972.

Table 3. Ambient Mercury Concentration - Comparison Values[1]

Sample Description	Concentration ng/m^3
Kilauea East Rift (This Study)	
Hg^0 Vapor	4-45
Total Particulate Mercury	below detection limit - 4
Atmospheric Concentrations	
Palo Alto, CA (vapor)	1-10
Los Altos, CA (vapor)	1-50
East Chicago, IN (particulate)	2-5
Niles, MI (particulate)	2 (typical)
Columbia, MO (particulate)	.2-.5
Chicago, IL (particulate)	3-38
Philadelphia, PA (particulate)	2 (typical)
Denver, CO (particulate)	2 (typical)
New York, NY (particulate, indoor)	1-41
New York, NY (particulate, outdoor)	1-14
Houston, TX (particulate)	<3
Beaumont, TX (particulate)	50
Toronto, Canada (particulate)	<1-4
Cincinnati, OH (total)	100
Charleston, WV (total)	170
"unpolluted air" (vapor)	8 (average)
Pacific Ocean (20 miles offshore)(vapor)	.6-.7
Pacific Ocean winds measured in California (vapor)	0.2 (average)
California (vapor)	1-50
Background, Arizona and California (vapor)	1.6-7.2
Kamchatka (vapor)	190
Moscow and Tula regions (vapor)	80-300
Non-minearalized, non-urban areas (total)	3-9
Ambient Air Quality Standards (24 hour Average)	
Bulgaria	300
Germany (Democratic Republic)	300
Israel	10,000
Romania	10,000
Soviet Union	300
Occupational Exposure Standards	
Czechoslovakia (inorganic)	50,000
Germany (Democratic Republic)(inorganic)	100,000
Germany (Federal Republic)(inorganic)	100,000
Great Britian (inorganic)	100,000
Hungary (inorganic)	20,000
Japan (inorganic)	50,000
Poland (inorganic)	10,000
USA[2] (total)	10,000
USA[3] (total)	100,000
USSR (inorganic - ceiling values)	10,000
USSR (Alkyl - counting values)	5,000
Volcanic Sources	
Mt. St. Helens Plume	
September, 1980 eruption	750-1800
Air of vent Breccias of mud volcanoes	300-700
Gases of mud volcanoes	700-2000
Gases, Mendeleev and Sheveluch volcanoes	300-4000
Gases from Hot Springs, Kamchatka and Kuriles	10,000-18,000

[1] Sources: Liptak, B.G., Air Pollution, Environmental Engineers' Handbook, Volume 2, 1974; Chemical Rubber Company, Handbook of Environmental Control, Volume 1, Air Pollution; U.S. Department of Labor, OSHA 2234, Mercury, Job Health Series, 1975; Noyes Data Corporation, 1974, Pollution Detection and Monitoring Handbook; U.S. Geological Survey Professional Paper 713, Mercury in the Environment, 1970; Lenihan, J. and Fletcher, W.W., 1977, Environment and Man, Volume 6, The Chemical Environment, Academic Press; and Varekamp, J.C. and Buseck, P.R., 1981, Mercury Emissions from Mount St. Helens during September 1980, Nature, Volume 293, pp. 555-556.

[2] American Industrial Hygiene Assoc. maximum recommendation for exposure - 8 hrs. per day, 5 days per week

[3] Occupational Safety and Health Administration, work place maximum level

atmospheric concentrations at other sites and communities outside of Hawaii can be made. Occupational Exposure Standards are also given.

It should be noted that elemental mercury vapor levels and particulate mercury levels in the rift zone are well below ambient air quality and industrial standard levels, but fall within the typical range of atmospheric concentrations.

Mercury concentrations in the East Rift Zone are also regulated by the inflow of trade winds from the ocean where mercury levels are extremely low.

RADON-222

Radon-222 is a radioactive gas naturally formed from the decay of radium contained in geologic materials. Due to the radioactivity of Radon-222 and its daughter products, and the fact that Radon-222 is a gas which can be inhaled, high Radon-222 concentrations are injurious to human health (Houck, 1984). Exposure to high levels of radon and its daughters is known to induce lung cancer. This has been documented by the excess cases of lung cancer among underground miners exposed to high levels of radon (Layton, 1981).

High radon emission rates are associated with volcanic and geothermal areas. Ambient concentrations of radon, measured in the Kilauea East Rift Zone Environmental Baseline Survey (Houck, 1984, page 106) range from 130 to 1000 pCi/m^3 (picoCurie of radiation per cubic meter) and up to 1960 pCi/m^3 in the remote Site B (see Figure 8)--an area of active volcanism. 130-1000 pCi/m^3 is considered to be more representative of the values to which rift zone residents are exposed. Table 4 shows that this range is not unusual for outdoor exposure levels and is well below indoor exposure levels of North American and European homes. Even the maximum level measured at the remote site is well below standards.

Table 4. Comparison of Radon-222 Activities with Indoor and Outdoor Values and Standards*

Location		Range of Reported Values (pCi/m^3)
KILAUEA E. RIFT (THIS STUDY)		130 - 1960
Kilauea E. Rift (excluding Remote Site B)		130 - 1000
Illinois	(outdoor)	50 - 1000
New York	(outdoor, city & State)	15 - 500
Ohio	(outdoor)	70 - 1040
Florida	(outdoor)	20 - 300
California	(outdoor)	2.5 - 10
Massachusetts	(indoor)	< 5 - 940
Tennessee	(indoor)	130 - 4800
Florida	(indoor)	30 - 3600
New York	(indoor)	60 - 390
Above Oceans		10
OSHA Uranium Mine Standard		66,000
U.S. EPA Indoor Standard for houses around inactive uranium mill tailings		4,000
California Ambient Air Standard		3,000
Houses built on Florida Phosphate Mining Regions:		
Level requiring remedial action		4,000
Level requiring reduction to a reasonably feasible level		2,000
Houses built on Canadian Uranium Mining Regions:		
Prompt remedial action required		30,000
Remedial action required		4,000
Investigation recommended		2,000
Sweden (maximum levels):		
Existing buildings		11,000
Houses undergoing remodeling		5,000
New houses		2,000
Union of Concerned Scientists:		
Remedial action indicated		> 5,000
Remedial action suggested		2,000 - 5,000
1% risk increase of dying of lung cancer increment (lifetime exposure)		4,000

*Data is from a collection of numerous studies compiled in: National Background Radiation, Report of Scientific Committee 43, National Council on Radiation Protection and Measurement, March, 1974, and, Indoor Air Pollution, 1983, Hileman, B., Environ. Sci. Technol., v. 17, n. 10, p. 469A.

Source: Houck, 1984

ARSENIC CONTAMINATION

The presence of arsenic in geothermal fluids can cause negative health effects including skin cancer if fluids are allowed to contaminate surface waters or ground waters.

Common practice is to inject residual geothermal fluids back into a geothermal reservoir for disposal, thus isolating spent fluids from drinking water supplies. Injection wells like geothermal wells are drilled past the ground water aquifer and cased so that no leakage to an aquifer can occur.

OTHER GASES

The Environmental Baseline Study for Kilauea East Rift included data on chlorine gas and carbon monoxide. Table 5, presenting survey measurements, standards, and biological impact values for chlorine gas, is provided for reference.

AMBIENT AIR QUALITY IN THE KILAUEA EAST RIFT ZONE

Quantification of pre-development concentrations of naturally occurring emissions in geothermal rift zones is essential in order to assess any future changes in emission concentrations resulting from development of the geothermal resources.

Quantification has been undertaken by the State Department of Planning and Economic Development in a two-year environmental baseline survey of the Kilauea East Rift Zone (Houck, 1983). Volume 1 of the survey report covers the period between December 1982 and December 1983. A second-year progress report for the period between January 1, 1984 and May 31, 1984 is also available.

The principal parameters measured in this study include atmospheric concentrations of particulate material, sulfur dioxide gas, hydrogen sulfide gas, chlorine gas, carbon monoxide gas, elemental mercury vapor, radon, elemental and organic content of particulate material, rainwater pH, elemental and anionic content of rainwater, and wind speed and directions.

Table 5. Comparison of Chlorine Gas Concentrations With Standard and Biological Impact Values

Parameter	Concentration ($\mu g/m^3$)
Site 2, multi-day[1] integrated samples	< 0.02 - 0.7
Site 4, multi-day[1] integrated samples	< 0.007 - 0.15
Remote Site A, multi-day[1] integrated samples	< 0.02 - 0.14
Remote Site B, multi-day[1] integrated samples	< 0.02 - 0.37
Remote Site D, multi-day[1] integrated samples	< 0.02 - 0.07
TLV[2]	1,500
Damage to some plants (2 hr. exposure), bleaching between veins, leaf abscission	316
Coleus (2 hr. exposure), incipient injury	1,770
Azalea (4 hr. exposure), incipient injury	2,500
Corn (1 hr. exposure) plants die	196,000
Odor threshold	450
Generally still tolerable for animals	≈ 4,741
No damage when repeatedly exposed (animals)	65,433
Exposure causes sickness	≈ 190,000
Respiratory rate increases during exposure	632,000 - 3,161,000
Death occurs	≈ 1,900,000
Brief exposure kills even large animals	3,161,000

[1] 1/25/83 - 12/10/83

[2] American Industrial Hygiene Assoc., Maximum recommendations for exposure, 8 hrs./day, 5 days/week

Source of Comparison Values: Chemical Rubber Co., Handbook of Environmental Control, Volume 1, Air Pollution, 1972.

Source: Houck, 1984

In January 1984, two addtional monitors were added to measure inhalable and respirable particles. Also, data from other research sources were collected to establish baseline conditions.

First-year results of the Environmental Baseline Survey have been summarized as follows (see Figure 8 for sites referenced):

(1) Total suspended particulate levels on the Rift Zone are extremely low. The combined effect of the drought, the brush fires, and the eruptions of Kilauea, which occurred during the study period, makes even these low TSP values higher than what would probably normally be characteristic of the Rift Zone.

(2) Sea salt aerosol, road and soil dust, volcanic emissions, diesel exhaust, and organic material (pollen, spores, vegetative fragments, and smoke particles) are the principal current sources of TSP.

(3) Sea salt aerosol is relatively more important at Sites 1, 2 and 3 than it is at Site 4 as a source of particles due to their closer distance to the coastline. Conversely, volcanic fume is more dominant at Site 4 due to its proximity to volcanic emission sources.

(4) Sulfate particulate material and, under certain conditions, heavy metals contained in particulate material can be related to volcanic emissions.

(5) Current hydrogen sulfide and chlorine gas levels are very low and well below biological impact levels. Occasional short term H_2S episodes have been observed at Site 4 and at Volcano Village. These episodes are at only modest concentration levels and are less than a day in duration.

(6) Sulfur dioxide concentrations due to volcanic activity can exceed standard values, values typical of urban areas, and human health and plant impact values for days at a time. Higher SO_2 values have been measured in the upper part of the Rift Zone than in the lower portion. In the absence of volcanic impact, SO_2 values are low.

(7) Rain water is slightly acidic in the Puna and Ka'u districts due to the long range transport of pollutants across the Pacific. Locally, additional acidification occurs due to volcanic emissions of SO_2, and rainfall collected within approximately ten kilometers downwind of sources of volcanic fume have a consistently lower pH. Conversely, sea salt aerosol reduces the acidity of rain, and areas closer to the coastline have a tendency to have a higher pH.

(8) The chemical composition of rain shows the impact of sea salt and, to a lesser extent, geological materials. The impact of sea salt on its chemical composition decreases with distance from the ocean (increase in elevation). Sulfate in the rain water samples is higher at Site 4 than at Site 2, again due to SO_2 emitted by the volcano. Nitrate is very low in the Hawaiian rain water samples. All trace elements which were capable of being measured to the level specified by drinking water criteria standards (except selenium) were found to be below the drinking water threshold values. The data for selenium is limited, but it appears that the drinking water threshold values may be exceeded for selenium in some rain water samples. Most conclusive is the fact that the pH of rainfall in the Puna and Ka'u districts is uniformly more acidic than the drinking water criteria range.

(9) Ambient mercury and radon values were more or less typical of atmospheric values nationwide. The impact of volcanic emissions on the atmospheric radon content could be seen by noting the higher values measured at the site closest to the current eruption area in Kahauale'a.

(10) The complexity of the land/sea breeze and trade wind interaction is apparent in the diurnal fluctuation of wind direction seen at Site 2 and the drainage wind phenomenon seen carrying volcanic fume from Kahauale'a over the Pali along the Chain of Craters/Kalapana Road.

(11) Both temporal and spatial variability in rainfall is dramatic in the Kilauea East Rift Zone area. This variability can effect the

magnitude of TSP material originating from such sources as road and soil dust and spores and pollen from vegetation.

The first-year report also summarizes data for each type of emission and provides for comparison, emission standards of other states and countries, as well as biological impact values for each type of emission and includes table from the Baseline Survey. Figure 8 shows the approximate location of survey monitoring stations in the Kilauea East Rift Zone.

EMISSIONS FROM GEOTHERMAL DEVELOPMENT AND CURRENT ABATEMENT TECHNOLOGY

The Geothermal Technology report, Circular C-108 of this series, provides a discussion of the current level of abatement technology available for use in developing and operating geothermal wells in Hawaii.

The recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the noncondensable gases.

Use of this system would enable facilities to comply with the proposed State Department of Health air quality standard for geothermal developments since this standard requires 98% of the H_2S present to be removed.

As noted in the Geothermal Technology report, given the characteristics of the HGP-A reservoir fluids and the available emission abatement technology which would be required to comply with proposed State air quality standards, geothermal facility cooling tower emissions should not be toxic and the plume should consist entirely of water vapor. Brine from the plant will be injected back into the geothermal reservoir.

Abatement of Radon-222 is unnecessary since the level emitted from the power plant is lower than most indooor levels where cement emits radon in most buildings.

STATE OF HAWAII, DEPARTMENT OF HEALTH PROPOSED AIR QUALITY STANDARDS FOR GEOTHERMAL DEVELOPMENT

The State Department of Health has drafted revisions to its Adminstrative Rules Chapter 11-59, Ambient Air Quality Standards, and Chapter 11-60, Air Pollution Control, covering geothermal activities (see appendix B).

Proposed revisions to Chapter 11-59-4 specify ambient air concentrations of carbon monoxide, nitrogen dioxide, suspended particulate matter, ozone, sulfur dioxide, lead and hydrogen sulfide. Under the proposed rule revisions, concentrations of hydrogen sulfide shall not exceed 139 ug/m^3 or 100 ppb.

Chapter 11-60 is to be amended by adding a new section 11-60-23.1 covering allowable emissions of particulates and hydrogen sulfide for geothermal wells and emissions of hydrogen sulfide only from geothermal power plants.

Chapter 11-60 is to be further amended to provide provisions for prevention of air pollution emergency episodes. Table 6 summarizes in outline form the proposed additions and revisions to the Department of Health Administrative Rules.

Chapter 11-60 is to be amended by adding sections dealing with geothermal wells and power plants and a section on air pollution emergency episodes.

Secton 11-60-23.1 defines geothermal wells, and sets standards for particulates and hydrogen sulfide. Prior to a well being connected to a power plant, well emissions shall not be in excess of five pounds of particulates, and five pounds of hydrogen sulfide, per one hundred pounds of each respective pollutant in the resource. After a well is connected to the power plant, emissions shall not exceed two pounds per 100 pounds of hydrogen sulfide in the geothermal resource. Permits to construct and operate a geothermal well are required of the well owner or operator.

Table 6. SUMMARY OF DRAFT REVISIONS/ADDITIONS TO DEPARTMENT OF HEALTH ADMINISTRATIVE RULES, CHAPTER 11-59

Chapter 11-59-4, Ambient Air Quality Standards:

- o rule limits the time averaged concentration of specified polluants dispersed or suspended in the ambient air.
- o limiting concentrations for a twelve-month period or a calendar year shall not be exceeded.
- o limiting concentrations for one-hour, eight-hour, and twenty-hour periods shall not be exceeded more than once in any twelve month period.
- o CARBON MONOXIDE
  1. Concentration shall not exceed an average value of ten milligrams per cubic meter of air during any one-hour period.
  2. Concentration shall not exceed an average value of five milligrams per cubic meter of air during any eight-hour period.
- o NITROGEN DIOXIDE concentrations shall not exceed seventy micrograms per cubic meter of air during any twelve-month period.
- o SUSPENDED PARTICULATE MATTER
  1. Concentration shall not exceed a geometric mean of sixty microgram per cubic meter during any twelve-month period.
  2. Concentration shall not exceed an average value of one hundred and fifty micrograms per cubic meter of air during any twenty-four-hour period.
- o OZONE concentrations shall not exceed one hundred micrograms per cubic meter of air during any one-hour period.
- o SULFUR DIOXIDE
  1. Average concentration shall not exceed the average value of eighty micrograms per cubic meter of air in any twelve-month period.
  2. Average concentration shall not exceed an average value of three hundred sixty-five micrograms per cubic meter of air in any twenty-four hour period.
  3. Average concentration shall not exceed one thousand three hundred micrograms per cubic meter of air during any three-hour period.
- o LEAD--elemental lead concentrations shall not exceed 1.5 micrograms per cubic meter of air during any calendar quarter.
- o HYDROGEN SULFIDE concentrations shall not exceed one hundred thirty-nine micrograms per cubic meter of air in any one-hour period.

Section 11-60-23.2 defines geothermal power plants and sets standards for hydrogen sulfide. Hydrogen sulfide emissions from a power plant shall not exceed two pounds per one hundred pounds of hydrogen sulfide in the incoming geothermal resource. The maximum allowable increase in hydrogen sulfide concentration in the ambient air above natural background level shall be thirty-five micrograms per cubic meter as a one-hour average. The maximum allowable increase may be exceeded once per twelve-month period at any one location. Permits to construct and operate a power plant are required.

Section 11-60-19, Prevention of Air Pollution Emergency Episodes, is designed to prevent excessive buildup of air contaminants during air pollution episodes. Episodes are classified as an air pollution alert, air pollution warning, or an air pollution emergency. Maximum concentrations for each level, alert, warning and emergency are set for sulfur dioxide, particulate matter, combined sulfur dioxide and particulate matter, carbon monoxide, ozone, nitrogen dioxide and hydrogen sulfide. Appendix B specifies these concentrations.

NOISE IMPACT

During the initial phases of geothermal development, persons in the vicinity of a geothermal site may be exposed to noise levels varying from 40 to 120 decibels, depending upon the distance from the well site. High noise levels are produced by well drilling, production testing, and well bleeding before connection to the generator. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise.

The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project (See Figure 9, Noise Characteristics at HGP-A).

Proposed county noise guidelines are 45 decibels at night and 55 decibels by day. It is expected that geothermal facilities will comply with this guideline.

HISTORIC AND ARCHAEOLOGICAL VALUES

Historical values, in this context, refer to the range of historical activities carried out by early Hawaiian residents. Archaeological values refer to all structures and artifacts that provide evidence of early habitation.

The Hawaiian land use concept of the ahupuaa is most useful in understanding the range of activities likely to have occurred within a rift zone area, as well as the potential for discovery of archaeological sites. For example, early coastal fishing villages often had inland agricultural fields. In addition to fishing and farming, various forest products were harvested from mauka or upland areas (i.e., koa for canoes, pulu for stuffing, ohia logs, birds for feathers) and early trail systems connected remote villages.

Evidence of these activities found in remaining archaeological sites is critical to reconstructing Hawaiian history and pre-history.

Geothermal development runs the risk of destroying such remaining evidence by site clearing and facility construction.

Estimates of likely impacts can be accomplished by (1) plotting the location of known archaeological sites within and nearby proposed subzones, (2) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, and (3) by archaeological reconnaissance surveys on site.

The Department of Land and Natural Resources, Division of State Parks, Outdoor Recreation and Historic Sites, under its Historic and Archaeological Program, maintains records of all known historical and archaeological sites in the State of Hawaii. A survey of available information was made to determine the type, extent and significance of sites within or nearby the proposed geothermal resource subzones.

Subzone boundaries were drawn on copies of Historic Sites maps showing known sites and their identification numbers. The most recent updated mapping, done under the Coastal Zone Management (CZM) program, was used, and where updated mapping was not available, other available maps prepared by DLNR, Historic Sites section were utilized.

Each site located within a proposed geothermal resource subzone or nearby its boundaries was identified and a review of Historic Sites section records made. This information has been summarized in Appendix D including State and National Register status.

A literature search was prepared for the Kahauale'a EIS (Appendix C). Similar searches accompanied by maps showing known sites would be prepared and on-site reconnaissance surveys performed, once geothermal development sites have been selected.

SCENIC AND AESTHETIC VALUES

Scenic and aesthetic values, in general, refer to landscape qualities likely to be impacted by geothermal development. Since most geothermal resource rift zones are located in remote wilderness areas, some of which are heavily forested, development of geothermal facilities can represent a visual intrusion.

Potential sources of visual intrusion include:

- o Clearing forested areas for construction of facilities
- o Temporary 2-3 month presence of drilling rigs
- o Night lighting of drilling rigs
- o Continued drilling for new wells, replacement wells, and injection wells (continued presence of drilling rig)
- o Permanent presence of power plant structures with cooling towers (50 to 65 feet in height)
- o Geothermal fluid transmission lines
- o Electric transmission lines (70 + feet in height)
- o Periodic presence of steam plumes above well heads and power plant cooling towers (under certain climatic conditions, steam plume may rise to 150 to 200 feet above the site)

Estimates of visual impact are accomplished by preparing an area wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen. A terrain analysis of visual impacts was completed for the preparation of the Kahauale'a Environmental Impact Statement (Kahauale'a Revised EIS, June 1982) and is provided here as Appendix D, for reference.

In preparing a terrain analysis of visual impacts, various observer location points are selected and view lines calculated at each site. The observer is assumed to have an eye level 10 feet above ground surface and power plant height is assumed to be 80 feet above ground level (alternate height considered is 65 feet). Profiles or visual perspectives are constructed to show the view lines from each observer location to a proposed power plant location. From such a profile, it is possible to determine the extent to which a site is visible from each observer location.

A similar terrain analysis should be included in environmental impact assessments for the development of specific sites within a geothermal resource subzones.

RECREATIONAL VALUES

Recreational values in remote areas, include hiking, hunting, fishing, and camping. These activities are usually not limited to specific areas and can therefore occur anywhere in a rift zone.

However, there are existing, well used hiking trails in many areas; some have names and are segments of longer trail systems. In some areas, pre-historic and historic Hawaiian trail systems remain. Often, local hikers and hunters develop trails by usage.

Public hunting areas referred to as game management areas are defined in Department of Land and Natural Resources rules and mapped for public convenience on handout sheets. Conditions for use of public hunting areas is specified in the rules; however, game may also be hunted on private land at any time with a valid hunting license and permission from the landowner.

The impact of geothermal development to remote area recreation uses such as hiking and hunting may result in the loss of segments of some trails and could affect the number of game animals present in the vicinity of the geothermal development.

STATE LAND USE DISTRICTS, COUNTY GENERAL PLANS AND EXISTING LAND USES

STATE LAND USE DISTRICTS

The State Land Use Commission has placed all lands within the State of Hawaii in four major land use districts: urban, rural, agricultural and conservation.

The standards for determining the boundaries of each land use district are set forth in Chapter 205, HRS, and are as follows:

Urban Districts include those lands that are now in urban use and activities or uses as provided by ordinances or regulations of the county within which the urban district is situated.

Rural Districts include activities or uses as characterized by low density residential lots of not more than one dwelling house per one-half acre and where small farms are intermixed with the low density residential lots.

Agricultural Districts include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters, mills, storage facilities, processing facilities; and roadside stands for the sale of products grown on the premises; agricultural parts and open area recreational facilities.

Conservation Districts include areas necessary for protecting watershed and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding communities, or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

The State Land Use Districts found in each of the potential geothermal resource rift zones are:

Kilauea East Rift Zone - Conservation, agricultural, and urban districts.

Kilauea Southwest Rift Zone - Conservation, agricultural, and urban districts.

Mauna Loa Southwest Rift Zone - Conservation and agricultural districts.

Mauna Loa Northeast Rift Zone - Conservation and agricultural districts.

Hualalai Northwest Rift Zone - Conservation and agricultural districts.

Haleakala Southwest Rift Zone - Conservation and agricultural districts.

Haleakala East Rift Zone - Conservation, agricultural, urban, and rural districts.

CONSERVATION DISTRICT AND SUBZONES

Of the four land use districts, the Conservation District is the only one administered by the State of Hawaii. Individual counties administer urban, rural and agricultural lands.

Chapter 183-41, HRS, established Conservation Districts and enabled the State Department of Land and Natural Resources to promulgate regulations to implement the statute. Implementation was accomplished under the Department's Administrative Rule, Title 13, Chapter 2. Under this rule, the Conservation District is further subdivided into five subzones: Protective (P), Limited (L), Resource (R), General (G) and Special Subzones (SS).

The Protective Subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. The Limited Subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the Resource Subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General Subzones are open space areas where specific conservation uses may not be defined, but where urban use would be premature. Special Subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area. At the present time there are four Special Subzones all located on the island of Oahu.

In accordance with the Administrative Rules of the Department of Land and Natural Resources, State of Hawaii §13-2-11, 12, 13, and 14 certain uses are permitted within each of the Conservation District subzones. The following uses are permitted in the Protective Subzones:

(1) Research, recreational, and educational use which require no physical facilites;

(2) Establishment and operation of marine, plant, and wildlife, sanctuaries and refuges, wilderness and scenic areas, including habitat improvements;

(3) Restoration or operation of significant historic and archaeological sites listed on the national or state register;

(4) Maintenance and protection of desired vegetation, including removal of dead, deteriorated and noxious plants;

(5) Programs for control or animal, plant, and marine population, to include fishing and hunting;

(6) Monitoring, observing, and measuring natural resources;

(7) Occasional use; and

(8) Governmental use not enumerated herein where public benefit outweighs any impact on the conservation district.

The following uses are permited in the Limited Subzone:

(1) All permitted uses stated in the (P) subzone;

(2) Emergency warning systems or emergency telephone systems;

(3) Flood, erosion, or siltation control projects; and

(4) Growing and harvesting of forest products.

The following uses are permitted in the Resources Subzone:

(1) All permitted uses stated in the (P) and (L) subzone;

(2) Aquaculture;

(3) Artificial reefs; and

(4) Commercial fishing operations.

The following uses are permitted in the General Subzone:

(1) All permitted uses as stated in the (P), (R), and (L) subzones; and

(2) Development of water collection, pumping, storage, control, and transmission.

COUNTY GENERAL PLANS AND LAND USE POLICIES

The Agricultural, Urban and Rural Land Use Districts are administered by the individual counties. Counties administer land uses through their General Plan and/or Community Plans.

The County General Plan sets forth the broad objectives and policies for the long-range development of the County. Community Plans provide more detailed schemes for implementing the General Plan.

Hawaii County

The County of Hawaii General Plan, adopted December 15, 1971, sets forth the following goals and policies for Land Use.

Goals:

1. Designate and allocate land uses in appropriate proportions and in keeping with the social, cultural, and physical environments of the County.
2. Protect and encourage the intensive utilization of the County's limited prime agricultural lands.
3. Protect and preserve forest, water, natural and scientific reserves and open areas.

Policies:

1. Zone urban-type uses in areas with ease of access to community services and employment centers and with adequate public utilities and facilities.
2. Promote and encourage the rehabilitation and utilization of urban areas which are serviced by basic community facilities and utilities.
3. Allocate appropriate requested zoning in accordance with the existing or projected needs of neighborhood, community, region and County.
4. Establish a "land zoning bank" from which land use zoning may be allocated to specified urban centers and districts.
5. Conduct a review and re-evaluation of the tax structure to assure compatibility with land use goals and policies.
6. Incorporate innovations such as the "zone of mix" into the Zoning Ordinance in order to achieve a housing mix and to permit the more efficient development of lands which have topographic and/or drainage problems.

7. Incorporate the concept of a "floating zone" for future industrial and retreat resort areas. This concept would allow flexibility in locating future needed developments in districts which cannot be pinpointed at this time, especially in the more rural and/or remote areas.

Land uses are categorized as follows in the plan:

Urban Centers:

High Density: Commercial, multiple residential and related services (general and office commercial; multiple residential--87 to 43.6 units per acre).

Medium Density: Village and neighborhood commercial and residential and related functions (3-story commercial; multiple residential--35 to 11.6 units per acre; single-family residential--5.8 units per acre).

Low Density: Residential and ancillary community and public uses (single-family residential--no more than 4 units per acre).

Industrial Area: Manufacturing and processing; wholesaling; large storage and transportation facilities; power plants; and government baseyards.

Resort Area: Hotels and supporting services.

Agriculture Area:

Intensive: Sugar; orchard; diversified agriculture; and floriculture.

High: Fertile soil.

Low: Less fertile soil.

Extensive: Pasturage and range lands.

Orchard: Those agricultural lands which though rocky in character and content support productive macadamia nuts, papaya, citrus and other similar agricultural products.

Public Lands: Federal, State, University and County-owned lands.

Open:

Parks and historic sites.

Conservation Area: Forest and water reserves; natural and scientific preserves; open; etc.

The five potential geothermal resource areas on Hawaii contain the following county designated land use categories:

Kilauea East Rift Zone - This area is comprised of conservation, low density, medium density, resort, open area, orchards, alternate urban expansion, and extensive agriculture zones.

Kilauea Southwest Rift Zone - This area is comprised of conservation, extensive agriculture, intensive agriculture, low density, medium density, open area, and orchard zones.

Mauna Loa Southwest Rift Zone - This area is comprised of conservation, orchards, intensive agriculture, and extensive agriculture zones.

Mauna Loa Northeast Rift Zone - This area is comprised of conservation and extensive agriculture zones.

Hualalai Northwest Rift Zone - This area is comprised of conservation, extensive agriculture, and orchard zones.

Maui County

The land use objectives and policies of the Maui County General Plan December 28, 1977 are as follows for Land Use.

Objectives:

1. Uses of land meeting the social and economic needs of the people.
2. Availability of agriculture lands that are well-suited and feasible for agricultural products.
3. A lifestyle pattern based on consistent and harmonious use of land.

Policies:

1. Discourage the unwarranted conversion of agriculture lands to non-agricultural uses.
2. Minimize the encroachment of urban uses on agriculture lands.

3. Provide for compatible alternative uses on non-productive agriculture lands.
4. Enhance agricultural land use activities by providing public incentives and encouraging private initiative.
5. Develop land use guidelines reflecting the individual character of the communities and regions of the County of Maui.
6. Guide land use development patterns in sympathy with an area's natural topographic features, environmental hazard constraints, scenic amenities and other natural resource potentials.
7. Maintain the opportunity to pursue a rural lifestyle.
8. Encourage land use methods that provide a choice of housing types and locations.
9. Continue programs to identify and preserve unique and significant historic sites and natural areas.
10. Provide a wide-range of compatible land uses based on individual, community, regional and county needs.
11. Ensure the effective protection and prudent use of Maui County's coastal areas.
12. Encourage the "most reasonable and beneficial use" of land by discouraging practices that promote "the highest and best use" concept of land use.
13. Establish guidelines and programs to further reduce land speculation.,
14. Guide and integrate the development of public facilities and infrastructures with established County land use policies.
15. Encourage the Hawaiian Homes Commission to establish additional homestead lands throughout the County of Maui.

The land use categories were obtained from various community plans covering the two potential resource areas of Maui. These community plans are mandated by the Charter of Maui County (1977) and the Maui County General Plan which was adopted on June 24, 1980 as Ordinance No. 1052.

Conservation:

This use is to protect and preserve wilderness areas, open spaces, beach reserves, scenic areas, historic sites, open ranges, watersheds, and water supplies; to conserve fish and wildlife; and to promote forestry and grazing. It is intended that all lands designated as Conservation be governed by the requirements and procedures of Chapter 205, HRS, as amended, and administered by the State Department of Land and Natural Resources.

Rural:

This use is to protect and preserve areas consisting of small farms intermixed with low-density, single-family residential lots. It is intended that, at minimum, the requirements of Chapter 205, HRS, as amended shall govern this area.

Agriculture:

This use is to provide areas for agricultural development which would be in keeping with the economic base of the County and the requirements and procedures of Chapter 205, HRS, as amended. It is also expected that the County will impose more stringent requirements on these areas to ensure their use for agriculture.

Reserve:

This is primarily for areas within the State Urban District which have low priority for urban development because of environmental concerns, such as natural hazard and resource areas, archaeological sites, and other considerations, or the costs entailed with development because of the lack of nearby or adequate public facilities and services.

Single-Family Residential:

This includes single-family detached and duplex dwellings.

Multi-Family Residential:

This includes apartment and condominium buildings that have more than two dwellings.

Business/Commercial:

This includes retail stores, offices, entertainment enterprises and their accessory uses.

Light-Industrial Use:

This is for warehousing and service and craft-type industrial operations.

Heavy-Industrial Use:

This is for major industrial operations whose effects are potentially noxious due to noise, airborne emissions or liquid discharges.

Hotel/Resort:

This applies to transient accommodations which do not contain kitchens within individual living units but may include a restaurant or small shops serving hotel guests.

Public/Quasi Public:

This includes schools, libraries, fire/police stations, government office buildings, public utilities, hospitals, churches, cemeteries, and community centers.

Airport:

This includes all commercial and general aviation airports.

Park:

This includes all public active and passive parks.

The two potential resource areas on Maui contain the following land uses:

Haleakala Southwest Rift Zone - This area is comprised of conservation, agriculture and park zones. The park area is located southwest of Kihei Road at Cape Kinau.

Haleakala East Rift Zone - This area is comprised of conservation, agriculture, rural, reserve, single-family residential, multi-family residential, business/commercial, light-industrial use, hotel/resort, public/quasi public, and park zones.

EXISTING LAND USES

Existing land uses in potential geothermal resource areas are characteristic of their respective zoning. Most potential areas are zoned conservation and may include forest reserve, national and state parks, other forested areas, brush and grass lands, and barren lava flows. Often conservation zoned lands provide habitat for native and rare or endangered species as well as hunting area, and watershed lands.

Potential resource areas zoned agricultural are used mostly for livestock grazing.

The only urban zoned areas are those located at Pahoa and Kapoho in the Kilauea East Rift Zone, Hawaii; and Hana, in the Haleakala East Rift Zone, Maui. The only Rural zoned area is located at Pahoa, Hawaii.

Table 7 summarizes existing land uses in each resource area.

COMPATIBILITY OF GEOTHERMAL RESOURCE DEVELOPMENT WITH SURROUNDING LAND USES, AND ZONING

Act 296 in addressing the designation of geothermal resource subzones requires assessement of each geothermal resource area by an examination of various factors including the compatibility of geothermal development and potential related industries with existing land uses and those uses permitted under Section 205-2, Hawaii Revised

Table 7. Land Use in Geothermal Areas

Description	Kilauea			Mauna Loa		Hualalai	Haleakala	
	NE Rift Lower	NE Rift Upper	SW Rift Kau	E Rift	SW Rift	NE Rift	NE Rift Hana	SW Rift
URBAN:								
Residential	●						●	
Commercial	●						●	
RURAL:								
Residential	●							
AGRICULTURE:								
Cropland	●	●						
Grazing	●	●	●	●	●	●	●	●
Residential	●	●			●			●
CONSERVATION:								
Forest Reserve	●	●					●	●
National Park		●	●					
State Park	●							
Other Forests	●	●	●	●		●	●	●
Brush & Grassland	●	●	●	●	●	●	●	●
Lava Flows (barren)	●	●	●	●	●			●
Endangered Mammal				●	●			
Endangered Bird				●	●	●		●
Wildlife Sanctuary				●	●			
Hunting Area	●	●		●	●			
Watershed							●	●

Statutes, relating to State Land Use Districts, Section 183-41, HRS, relating to Conservation Districts and all uses permitted under County general plans or land use policies.

Act 296 allows geothermal resource subzones to be designated within any of the four state land use districts--urban, rural, agricultural and conservation. As such, once subzones are established, geothermal facilities could be located adjacent to any land use existing or permitted in any of the four districts.

Compatibility simply means being capable of living or performing in harmonious combination with each other. Some land uses are obviously more compatible than others depending on their characteristics.

As noted in the Flora and Fauna Section of this report, forested areas may be categorized by the amount of canopy and quantity of native forest present, the assumption being that undisturbed closed canopy native forest would be the most susceptible to disruption by geothermal development. Thus, geothermal development would be least compatible with a Category 1 forest consisting of exceptional native forest with a closed canopy and over 90% native cover. Category 2 forest consists of mature native forest with over 75% native canopy. Category 2A consists of native scrub and low forest and Category 3 consists of cleared land, non-native forest, or bare ground or lava. Category 3 forest is considered more compatible with geothermal development than Category 1 forest. However, construction of a geothermal power plant in Category 2A native scrub and low forest or in Category 3 open, cleared land or barren-lava flows result in visual intrusions which might be otherwise hidden in a Category 1 or 2 forest.

Conservation districts constitute a large percentage of the potential resource areas. Each area within the conservation district has permitted uses. In each of the subzones mentioned, Protective, Limited, Resource and General; the use of the area for "monitoring, observing, and measuring natural resources" is permitted. In this respect exploration of geothermal resources can be allowed in a conservation district. The development of these resources can then eventually lead to widespread public benefit. The use of lands within a conservation district in which "governmental use not enumerated herein where public benefit outweights any impact on the conservation district" is permitted. In managing the uses of conservation lands, careful analysis of the proposed use is required. Thus, only when the benefits of the proposed use are determined to be greater than any impact on the land, will the use be permitted.

In addressing land use compatibility, several assumptions must be made.

- o Ambient air quality will not be effected since it is expected that current abatement technology will be fully utilized in compliance with proposed State Department of Health air quality standards for geothermal development.
- o Proposed County of Hawaii Noise Guidelines of 45 decibels at night and 55 decibels by day will be complied with. It is also assumed that the County of Maui will adopt similar noise guidelines in reference to geothermal activities.
- o Geothermal facility siting will be adjusted to avoid endangered plants and significant archaeological or historical sites.
- o Visual impacts will be minimized by adjusting the location of the site, the alignment of structures so as to present the smallest possible aspect and by blending structures with surroundings by painting appropriately and by use of non-reflective, light absorbent materials and textures and by shielding facilities from view by locating behind a puu, or hill, or by placement in a forested area.
- o Impacts will be further minimized by use of buffer zones surrounding geothermal facilities.

EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

Evaluation of impacts on potential geothermal resource areas was accomplished by reviewing available information for each geothermal resource area. Information on meteorology, surface water, ground water, underground injection control areas, existing land uses, flora and fauna and historic and archaeological sites was developed by mapping on a series of overlays for each geothermal resource area. The following evaluation is the product of the overlay mapping and data review process.

KILAUEA EAST RIFT ZONE

Under trade wind conditions, during the day, northeast trade winds pass through the entire rift zone. Wind speeds vary from light to fast depending on the topography. The southern half of the rift zone will have moderate to fast trade winds, while the northern half will have light to moderate wind speeds. At night, the moderate northeast trades pass through the eastern end of the zone while gentle to moderate northerly drainage downslope winds pass through the remainder of the rift zone.

Under non-trade wind conditions, during the day, gentle to moderate sea breeze-upslope winds from the southeast through southwest pass through the rift zone. At night, gentle to moderate downslope winds from the higher slopes drain down through the rift zone from the north through west.

Rainfall is heavy over most of the central northeast half of the rift zone--over 100 inches a year. Rainfall falls off sharply at the western end of the rift zone from 100 inches a year to 35 inches a year in a short distance of less than 2 miles. The western end of the rift zone has the lowest rainfall.

Hawaii Volcano National Park Headquarters at 3,970 feet elevation, Pahoa at an elevation of 650 feet, and Pohoiki at an elevation 10 feet can be used as representative temperature stations in the rift zone. Pahoa and Pohoiki have average annual maximum and minimum temperatures of 78.2°F and 63.4°F, and 81.2°F and 67.2°F, respectively. The average annual temperature at National Park Headquarters is 68.1°F and 52.9°F.

There are no known surface streams or natural water storage features in the Kilauea East Rift Zone, with the exception of Green Lake in Kapoho Crater.

Ground water occurs as dike water and basal water in the Kilauea East Rift Zone. The only known perched water exists north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic gradients along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone on ground water movement. The effectiveness of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels.

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 19,000 mg/l. Because of the effects of mixing, most ground water at the coast is brackish. Salinity and temperature vary greatly north and south of the rift zone. Wells and shafts north of the rift zone are characterized by lower temperatures and lower salinities. Wells in and near Keaau have water temperatures of 66° to 68°F. The water temperature of wells near Pahoa ranges between 72° and 74°F. Wells located more than 3 miles inland generally have a chloride concentration of less than 20 mg/l. South of the rift zone, high well-water temperatures and salinities are encountered. The water temperature of the Malama-Ki well, No. 2783-01, in 1962 was 127-130°F with salinity between 5500 and 7000 mg/l at pumping rates of 100 to 480 gpm. The water temperature of thermal test well No. 3 in 1974 was 199°F, with salinity of 2000 mg/l. The average chloride content of ground water south of the rift zone is probably greater than 3000 mg/l, probably due in part to heating of sea water by volcanic activity below the basal lens. The warmer, less dense sea water rises, contaminating the fresh water in the basal aquifer.

LOWER KILAUEA EAST RIFT ZONE

Property in the lower portion of the Kilauea East Rift Zone is owned by six large area landowners and numerous small area landowners. Large area landowners include the State of Hawaii, Bishop Estate, Campbell Estate, Puna Sugar Company, Kapoho Land Development Corporation, and Tokyu Land Development Corporation.

Property within the Lower East Rift Zone is zoned Agricultural, Conservation, Urban and Rural. It should be noted that existing land uses in Agricultural zoned areas include both cultivated and uncultivated land, and agricultural subdivisions. Agricultural subdivisions are designated by the County of Hawaii as A-1a, meaning an agricultural subdivision of one acre lots. Five one-acre subdivisions are located within the rift zone boundaries, and include Leilani Estates, and Nanawale Subdivision. Conservation zoned areas include Forest Reserve lands, the Wao Kele O Puna Natural Area Reserve and the Kapoho Lava flow of 1960. Urban areas within the rift zone boundaries include Pahoa, Kaniahiku Village and a small portion of the Kapoho Beach Lots.

Lava flows in the Lower East Rift Zone include flows dated 1750, 1790, 1840, 1845, 1955, 1960, 1961, and 1983.

Forested areas in the Lower East Rift Zone consist primarily of Category 2 and 2A forest, mature native forest with over 75% native cover and native scrub and low forest. Isolated areas of Category 1 exceptional native forest with over 90% mature cover and closed canopies do exist in the Keauohana Forest Reserve, consisting of ohi'a-lama forest, in the vacinity of Puu Kaliu and at higher elevations in the Wao Kele O Puna National Area Reserve. Category 3, bare lava, cleared land is more evident in coastal area, especially in the Kapoho area, at Cape Kamukahi.

There is no endangered species essential habitat in the Puna area, since large portions of the area are either cleared agricultural land or bare lava.

Five historic sites are located in the Lower East Rift Zone:

Site No. 7388 - Pahoa District, town.

Site No. 4295 - Pualaa Complex, including an ancient holua slide.

Site No. 2501 - Kapoho Petroglyphs, considered unique, and placed on the State Register of Historic Sites.

Site No. 7492 - Lyman Historic Marker

Site No. 2500 - Kukii Heiau, reamins of heiau built by Umi on his tour of Hawaii after coming to power.

Development of geothermal resources in the Lower East Rift-Zone has been underway since 1973-74 with the issuing of geothermal resource mining leases for four areas, designated GRML R-1, R-2, R-3, and R-4. Development of additional sites in the Lower East Rift zone will not impact any endangered species essential habitat, but may impact existing communities in terms of noise and aesthetics. The provision of a buffer zone will help to mitigate such impacts. Air Quality will not be impacted, since it is expected that given current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

UPPER KILAUEA EAST RIFT ZONE

Property in the Upper East Rift Zone is owned by four large area landowners, the United States of America (Hawaii Volcanoes National

Park), the State of Hawaii, Bishop Estate, and Campbell Estate. Smaller holdings owned by various individuals are found in the Royal Gardens Subdivision along the coast and in urban and agricultural zoned areas in the Kilauea-Olaa area at the mauka boundary of the rift zone.

The Upper East Rift Zone is primarily zoned Conservation, Protective, Resource and Limited Subzones. Exceptions are the Ainahou Ranch land, Royal Gardens Subdivision, zoned for agricultural use, and the urban and agricultural zoned areas in the Kilauea-Olaa area.

Existing land uses include the Hawaii Volcanoes National Park (the largest area), forested areas in Kahauale'a, a grazed area in the vicinity of Ainahou Ranch, a portion of the Wao Kele O Puna Natural Area Reserve, and the Volcano and Royal Gardens Subdivisions. Also included are portions of the Kilauea Forest Reserve, Kilauea Military Camp, and Kilauea Golf Course.

Included on the list of existing land uses is the Campbell Estate/True Mid-Pacific Geothermal Development area as approved for exploration by the Board of Land and Natural Resources in 1983.

Forested areas in the upper portion of the East Rift Zone consist primarily of Category 1, exceptional native forest with over 90% native cover and closed canopy, and Category 2 mature native forest with over 75% native cover interspersed with bare lava flows, dated 1968-1973, 1977 and 1983-84.

Essential endangered species habitat for 'o'u encompasses a major portion of the Kahauale'a area, and extends into the Hawaii Volcanoes National Park land to the south. The Dark-rumped Petrel is known to nest in Napau Crater and I'o have established territory at Makapuhi Crater and at lower elevations in the vacinity of the Royal Gardens Subdivision.

There are no known archaeological sites within the Upper East Rift zone.

Development of geothermal resources in the Kilauea Upper East Rift zone will be limited to areas outside the Hawaii Volcanoes National Park. Air quality within surrounding areas will not be impacted since it is expected that, given the current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

Site development may impact endangered o'u habitat; however, as stated in the Kahau'alea Environment Impact Statement (June 1982), "the minimal removal of vegetation and trees within the Kahau'alea project area should not significantly threaten the O'u." (pg. 5-11).

It should also be noted that a portion of the O'u habitat has been lost due to recent lava flows.

KILAUEA SOUTHWEST RIFT ZONE

Under trade wind conditions, during the day, moderate to moderately strong northeast trade winds are expected to sweep through the rift zone. At night moderate drainage winds from the upper slopes of Mauna Loa should sweep through the rift zone from the north.

Under non-trade wind condition, during the day, light to moderate southerly sea breeze-upslope winds are expected to pass through the rift zone. At night, the light to moderate drainage winds from the north are expected to pass through the rift zone.

There is great variation in the amount of rainfall over this rift zone--from about 100 inches a year at the northern end of the rift zone near Hawaii Volcano National Park Headquarters to about 20 inches a year at the southern end of the rift zone near Hilina Pali in the Kau Dessert. The greatest variation in rainfall is at the upper end of the zone where in the short distance of about a mile from the National Park Headquarters to Halemaumau, the rainfall drops from 100 inches a year to 50 inches a year. There are no rainfall stations in the Kau Dessert.

Hawaii Volcano National Park Headquarters, at 3,970 feet elevation, with an average maximum and minimum temperature of 68.1°F and 52.°F, respectively, is the only temperature station in the rift zone.

There are few streams in the Kilauea Southwest Rift Zone because the water quickly percolates into the young and highly permeable lava flows. A few well-defined stream channels are found between Waiahaka Gulch, near Kapapala Ranch, and Hilea Gulch. No stream has continous flow into the sea, and flood flows reach the sea infrequently and only for short periods.

Ground water in the coastal areas of the rift zone is brackish; at higher elevations dike confined water is present. The Underground Injection Control line is set at an elevation of 200 feet in most of the coastal area but drops to an elevation of 100 feet within the rift zone near Waiapele Bay. Lava flows within the rift zone are dated 1823, 1868, 1920, 1971 and 1974.

Property within the Kilauea Southwest Rift Zone is owned by the State of Hawaii, United States of Amercia (Hawaii Volcano National Park), Bishop Estate, Ka'u Sugar, International Air Service, Seamountain Hawaii, C. Brewer, and a number of small parcel landowners.

Rift zone areas are zoned either Conservation, Resource and Limited Subzones, or Agricultural. All rift zone areas, except for National Park lands, are presently used for grazing.

The nearest urban or residential areas are Pahala, north of the rift zone, and Punaluu, west of the rift zone. Both communities essentially border the rift zone area.

This area is poorly characterized biologically. It was not included in USFWS vegetation mapping. The area is generally disturbed, with some pockets of native scrub along the coast and near the boundary of the national park, and is of little biological significance since it contains no endangered species habitat.

There are no known archaeological sites within this subzone.

Development of geothermal resources in portions of this rift zone, outside the National Park, would probably result in minimal environmental impact.

Development proximity to the Pahala and Punaluu communities may result in aesthetic impact. Air Quality will not be impacted since it is expected, given the current technology level that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal development.

MAUNA LOA NORTHEAST RIFT ZONE (KULANI)

Tradewinds during the day diverge around Mauna Loa and pass through the rift zone from the east to southeast. At night, reverse flow results from drainage of mountain breeze-downslope winds. Under non-trade conditions, light to moderate sea breeze-upslope winds flow through the rift zone from southeast to east. At night, mountain breeze downslope winds flow from the west.

Rainfall is heavy--150 inches a year at the 3,500-foot elevation to 60 inches a year at the 7000 foot elevation. Kulani Camp receives 102 inches a year (elevation 5,170 feet). Temperature at Kulani Camp ranges from an average annual maximum of 63.5°F up an average annual minimum of 46.5°F.

There are no known surface streams in this subzone area. Dikes occur above the 5400-foot elevation. The subzone area ranges in elevation from 3600 feet to 7000 feet.

Property within the proposed subzone is owned by Bishop Estate and the State of Hawaii, and is zoned Agricultural and Conservation. The nearest residential area is Kaumana on the north, approximately 6 miles from the subzone boundary. Volcano House in the National Park is approximately 8 miles from the southern subzone boundary.

Existing land uses within the proposed subzone boundary include the Agricultural zoned grazing land belonging to Bishop Estate and the State's Kulani Honor Camp, located in the Conservation District, Resource Subzone. The remaining lands within the subzone are forested and includes portions of the Mauna Loa, Kilauea, and Upper Waiakea Forest Reserves and two game management areas on the northwest and southwest corners of the subzone. Puu Makaala Natural Area Reserve is included in the southeast corner of the subzone.

Forested areas consist of Category 1, exceptional native forest; closed canopy with over 90% native cover. The remaining forest areas, consist of Category 2, mature native forest with over 75% native canopy. Forested areas in the upper and northern portion of the proposed subzone are dissected by recent lava flows dated 1852, 1942, and 1984.

Category 1 forests include tall Metrosideros polymorpha (Ohia lehua), and Acacia koa (koa) with native shrubs and tree ferns (Cibotium spp. hapuu). Category 2 includes moderate to tall Ohia lehua and koa, with native shrubs and ferns. Category 2A includes scattered Ohia lehua and Mamane, in some areas.

Mauna Loa forests within the subzone area provide habitat for four endangered forest bird species; the Hawaii Creeper, Akepa, Akiapola'au and the 'O'u, and the Nene. The Mauna Loa East Rift forests have been designated as essential habitat for the four endangered forest birds. In addition, 'Io, the Hawaiian Hawk, is known to nest at two sites, one on the lower slopes of Kulani Cone and a second site directly due West at an elevation of 5500 feet.

It should be noted that the designated essential habitat area includes the grazed agricultural zoned areas belonging to Bishop Estate since these areas contain both Category 1 and 2 forests as well as open areas. There are no known archaeological sites within the subzone area.

Development of a geothermal resource in areas other than the cleared grazed agricultural land may impact the four endangered forest bird species and the Nene by disturbing essential habitat areas.

MAUNA LOA SOUTHWEST RIFT ZONE (KAHUKU RANCH)

There are no wind data in this rift zone. Under trade wind condition, during the day, the lower half of the rift zone is expected to have light to moderate easterly trades passing through the rift zone. The northern upper half of the rift zone will likely have light to moderate upslope winds from the south. During the night, light to moderate northerly mountain breeze-downslope winds are expected to flow through the rift zone.

Under non-trade wind conditions, during the day, light to moderate southerly upslope winds are expected to pass through the rift zone. During the night, gentle to moderate drainage winds from the higher slopes are expected to pass through the rift zone from the north. Precipitation ranges from 40 to 50 inches decreasing at the upper elevations to 40 inches.

No surface streams are found within the subzone area. Dikes are found in the upper elevations of the subzone area; basal ground water is fresh, and the UIC line lies to the south outside the subzone area. There are no existing wells within the subzone area.

The subzone area is almost wholly owned by the S.M. Damon Estate, except for a small portion on the eastern subzone boundary which is state-owned.

Existing land uses within the potential subzone area include grazing land, a portion of the sparsely settled Hawaiian Ocean View Estates, and forest lands. The subzone boundary extends makai of Highway 11, to the Kahuku Ranch area. The nearest population centers are to the east, Waiohinu and Naalehu towns, and Kiolakaa-Keaa Homestead area. The subzone area is zoned agricultural and conservation.

Forested areas consisting mostly of mature native forest, with over 75% native cover, are interspersed with areas of bare lava from flows dated 1886, 1887, 1907, 1916, and 1926.

Above the 5000-foot elevation, forested and bare lava areas provide habitat for the Nene and two species of endangered forest birds, Hawaiian Creeper and Akiapolaau. On the eastern boundary between the 3000-foot and 3600-foot elevations, three species of endangered forest birds (Akepa, Akiapolaau and Hawaiian Creeper) occupy an area designated as exceptional native forest, with a closed canopy and over 90% native forest cover. The subzone area lies to the east of the Manuka Natural Area Reserve; no portion of the reserve is included in the proposed subzone.

Historic sites are found only at the subzone perimeter at Kahuku Ranch. No significant archaeological or historic sites were recorded within the subzone boundaries.

Development of geothermal resources in the lower, agricultural-zoned portion of the proposed subzone may result in minimal environmental impact provided a buffer area is maintained between the geothermal development site and the Hawaiian Ocean View Estates.

HUALALAI NORTHWEST RIFT ZONE

Although no wind instrumentation exists on Hualalai, knowledge of other upland areas indicated that light to moderate upslope sea breezes converge on Hualalai during the day; at night, the reverse gentle to moderate downslope mountain breezes diverge in all directions from the Hualalai Summit. Rainfall varies from light to moderate, from 30 to 40 inches a year.

There are no known surface streams in this area; however south of the subzone area, man-made catchments and collecting ponds are used to provide water for ranch purposes. Dikes occur in this subzone and elevations range from 3400 feet to 7200 feet.

Property within the subzone is wholly owned by Bishop Estate and zoned Conservation except for a triangular section on the southeast slope, and two small segments along the northwest perimeter that are zoned agricultural. The nearest residential areas occur along the Mamalahoa Highway to the west; Kailua-Kona is located seven miles southwest of the subzone. Except for the triangular shaped agricultural land, which is grazed, all other land within the subzone is forested. Approximately one-half of the forested area lies within the Kaupulehu Forest Reserve.

Forested areas consist of mature native forest, with over 75% native canopy. Exceptional native forest with over 90% native canopy is found along the subzone boundary between elevations of 4000 to 6500 feet. Species composition consists primarily of Metrosideros polymorpha (ohia lehua), Acacia koa (koa), and Sophora chrysophylla (mamane). The subzone is crossed by a single lava flow, the Kaupulehu Flow.

Hualalai slopes within the subzone area provide habitat for four endangered species. The species composition varies with elevation. Between 3200 feet and 6000 feet Alala, Hawaiian Creeper and Akepa are found; between 6000 and 7000 feet Hawaiian creeper, Akepa and Nene are found; and above the 7000-foot elevation, only Nene.

No archaeological or historical sites have been recorded within the subzone area.

Development of geothermal resource in areas other than the grazed agricultural zoned portion of the subzone may impact the endangered species known to exist within the proposed subzone area. Alala, the Hawaiian Crow, is reported to number fewer than 20 individuals. Disturbance of their Hualalai habitat may cause further decline of this species and, possibly, its extinction.

HALEAKALA SOUTHWEST RIFT ZONE

Wind data for coastal sites indicate that under tradewind conditions, during the day light to moderate sea breeze-upslope winds from the southeast and the west flow from the coast to upper elevations. At night the reverse, mountain breeze-downslope winds occur. Similar sea breeze, mountain breeze winds, occur during non-tradewind conditions.

Rainfall in the rift zone ranges from 16 inches a year in coastal areas to 54 inches a year near Polipoli Spring.

Average annual maximum and minimum temperatures at the coast in the rift zone are expected to be about 84°F and 64°F, respectively; at 3000 feet 72°F and 55°F could be expected, and at 7000 feet a maximum of 63°F and a minimum of 44°F.

There are no know surface streams in this geothermal resource area. Several springs along the mauka northern fringes of the area provided water for minor uses, including camp water for the Polipoli Mountain Park.

Ground water in the rift zone is brackish below 1600 feet level and fresh basal water above. However, the rift zone also contains dike-confined ground water.

Property within the rift zone is owned by the State of Hawaii, Ulupalakua Ranch and other individual holders of smaller parcels. The coastal portions of the rift zone and mountain areas above 5000 feet are zoned Conservation, Protective, and General Subzones, and Resource Subzone, respectively. All mid-level areas not zoned Conservation are zoned for agricultural use.

The Ahihi-Kinau Natural Area Reserve from Kanahena to Keoneoio, including near-shore submerged lands, is located in the coastal portion of the rift zone. This Natural Area Reserve contains anchialine pools, marine ecosystems and the last lava flow (dated 1790) on the Island of Maui. Upslope, Ulupalakua Ranch land is used for grazing. The upper most portion of the rift zone above 5000 feet is designated as the Kula and the Kahikinui Forest Reserves. Polipoli State Park is located along the northern rift zone boundary. The nearest urban or residential areas are Makena, one mile north of the rift zone boundary; Ulupalakua Ranch, immediately northwest of the rift-zone along the Kula/Piilani Highway; and Keokea, approximately 2 miles northwest of the upper portion of the rift zone. "Science City" and the perimeter of the Haleakala National Park are located five miles upslope of the upper boundary of the rift zone.

Vegetation in the Haleakala Southwest Rift Zone consists of native scrub vegetation and some exotic tree plantings as well as substantial areas of pastureland with occasional forested areas. The lower portions of the rift zone are barren lava with isolated pockets of Category 1, exceptional native forest with closed canopy of over 90% native cover.

There is no endangered species habitat in this rift zone, although the middle elevations contain some very valuable, although disturbed, dry native forest.

There are five known archaeological sites in or on the perimeter of the rift zone:

1. Poo Kanaka Stone (site #1021) located near the Kula Highway and has been placed on the State Register of Historic Sites;
2. Puu Naio Cave (site #1009) located on the southwest rift zone boundary at an elevation of 1100 feet; also on the State Register;
3. Kalua O Lapa Burial Cave (site #1017) located at the eastern boundary of the Ahihi-Kianu Natural Area Reserve;
4. Maonakala Village Complex (site #1018) a coastal village site, also within the Natural Area Reserve;
5. La Perouse Archaeological District located at the southern boundary of the rift zone and on the State Register.

Development of geothermal resources within the grazed agricultural zoned portions of the rift zone will result in minimal environmental impact since no endangered species habitat is present.

Makena residential and resort developments, Ulupalakua Ranch and upslope, the Haleakala "Science City" may be affected aesthetically. Air quality in urbanized areas will not be impacted since it is expected, given the current level of technology, that all air quality impacts will be abated so as to comply with State Air Quality standards for geothermal resource development.

HALEAKALA EAST RIFT ZONE

In coastal areas, during tradewind conditions, northeast tradewinds prevail during the entire day and night. Wind speeds are moderate during the day and light at night. During a non-tradewind conditions, the winds are almost calm during the night and light during the day. The direction of the wind is from the south during the night and from the west during the day, which is opposite of what would be expected under the sea breeze-upslope winds during the day and mountain breeze-downslope winds during the night.

In upper areas, northeast tradewinds continue across the rift zone during the day and the night, however mountain breeze downslope winds meet the trades somewhere mid-level in the subzone.

Under a non-tradewind condition, gentle to moderate daytime sea breezes flow upslope and night time mountain breezes move downslope.

The average annual rainfall in the upper half of the rift zone is 200 inches with a possible maximum of over 300 inches on the northern side of the zone. Rainfall decreases toward the east to 65 inches a year at the coast.

At Hana Ranch the average annual maximum temperature is 80°F, and the average anuual minimum is 67.4°F.

Extrapolated average annual maximum and minimum temperatures at upper elevations are 72.4°F/56.8°F at 2500 feet; and 58.9°F/45.4°F at 7000 feet.

Streams in the Haleakala East Rift Zone are ephermal in spite of the high rainfall. The rocks are highly permeable, allowing all but the heaviest rains to sink rapidly into the ground. Rising from sea level at Hana Bay to the 7000-foot level near the eastern rim of Haleakala Crater, the area's rugged topography contains the headwaters of the several tributaries of Kawaipapa Gulch along the resource area's northern boundary and Moomoonui Gulch along the southern boundary. The makai area contains the intermittent Holoinawawae Stream that empties into Hana Bay.

Dikes occur throughout the middle and lower portions of the rift zone. The Underground Injection Control (UIC) line is set at an elevation of 200 feet.

Property within the rift zone is owned by the Hana Ranch, (lower elevations), the State of Hawaii (mid and upper elevations) and the United States of America (upper-most elevations). Smaller parcels in coastal areas belong to other landowners.

Lower elevation Hana Ranch land is zoned for agricultural use and is grazed. State land above the Hana Forest Reserve Boundary is zoned Conservation, Protective and Resource Subzones and is also designated as a Public Hunting area where wild pig and goat can be hunted year-round.

Hana Town and its rural community are located within the proposed subzone area along the coast.

Forested areas above 3000 feet uniformly consist of Category 1 exceptional native forest, closed canopy with over 90% native cover. Below the 3000-foot level the forest is more disturbed and gradually blends into Category 2, mature native forest with over 75% native canopy. Below the 1000-foot level the forest gives way to pastureland with occasional forested areas.

Forested areas above the 5000-foot level provide habitat for three endangered forest birds, the Maui Parrot bill, the Crested Honeycreeper, and the Akepa. Akepa habitat extends to lower elevations to the 4200-foot level.

All known archaeological sites are at or below the 200- foot level. Site No. 1078, at 200 feet is a fishing shrine which is on the State Register of Historic Places. Six other sites are located at lower elevations in coastal areas in rural and urban zoned areas.

Development of a geothermal resource in the Haleakala East Rift Zone in areas other than the grazed agricultural lands below the 1000-foot level may impact native forest bird habitat and above 4200 feet, endangered forest bird habitat. However, development of a geothermal resource below the 1000-foot level in grazed agricultural land could place a well and power plant as close as 7000 feet from the center of Hana Town. Quite clearly, the rural lifestyle of the Hana Community could be affected.

REFERENCES

METEOROLOGY

Rainfall:

National Oceanic and Atmospheric Administration, Climate of Hana, HI, Climatography of the U. S. No. 20. April 1978.

State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, Median Rainfall, State of Hawaii, Circular C88, June 1982.

Temperature:

State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, Average Maximum and Minimum Temperatures.

Wind:

Harland Bartholomew and Associates Climatological Data For Wailea, Maui, prepared for The Matson Navigation Co., S.F., CA December 1960.

True/Mid-Pacific Geothermal Venture in coordination with Campbell Estate, Revised Environmental Impact Statement for the Kahauale'a Geothermal Project, 1982.

Ekern, Paul C. and Alfred J. Garrett. Project Ahupua'a, Solar Meteorological Field Measurements on the Island of Hawaii. Summer, 1978-2. Eastern Flank of Mauna Loa. UHMet 79-04 Dept. of Metoeorlogy, University of Hawaii, August 1979.

Ekern, Paul and R. Becker. Project Ahupua'a, Solar Meteorological Field Measurements on the Island of Hawaii, Summer 1978-5. Southern Flank of Mauna Loa, Dept. of Meterology, University of Hawaii, 1979.

Leopold, Luna B., The Interaction of Trade Wind and Sea Breeze, Hawaii, J. of Meteorology, Vol. 6, No. 5, October 1949.

Steven W. Lyons. Summer Weather on Haleakala, Maui, UHMet 79-09, Dept. of Meteorology, University of Hawaii, April 1979.

Mendonca, Bernard G., Local Wind Circulation on the Slopes of Mauna Loa, J. of Applied Meteorology, August 1969.

Mendonca, Bernard and Wayne Iwaoka, The Trade Wind Inversion at the Slopes of Mauna Loa, Hawaii, J. of Applied Meteorology, April 1969.

Peterson, Carl M., The Trade Wind Regime of Central and Western Maui, Tech. Memorandum No. 1, Weather Bureau, January 1966.

Schroeder, Thomas A., Project Ahupua'a, Solar Meteorolgical Field Measurements on the Island of Hawaii. Summer 1978-3. Trade Wind Interactions with Local winds in South Kohala. UHMet 79-05, Dept. of Meteorology, University of Hawaii, February 1980.

Schroeder, Thomas A., Thomas G. Tarlton, and P. Anders Daniels, Maui County Wind Power Survey, Part 2: Molokai Mobile Sampling Program 21 June to 31 July 1977, Part 3: Maui Fixed Station Data September 1976 to July 1977, UHMet 77-04, Dept. of Metoeology, University of Hawaii, October 1977.

FLORA AND FAUNA

Berger, A.J., Hawaiian Bird Life, University Press of Hawaii, Honolulu, 1972,

Carlquist, S., Hawaii: A Natural History, Natural History Press, Garden City, New York, 1970.

Carson, H.L., personal communication 5/31/84.

Corn, C., personal communication 4/27/84.

Christensen, C., personal communication 5/30/84.

Griffin, C., personal communication 5/1/84.

Jacobi, J., Mapping and Natural Vegetation of the Hawaiian Islands, XV Pacific Science Congress, Dunedin, New Zealand, 1983.

_____, personal communication 5/28/84.

Kepler, C. and M. Scott Distribution and Behavior of the Hawaiian Hoary Bat, unpublished manuscript, U.S. Fish and Wildlife Service, 1984.

Lassetter, J. Stuart and Charles R. Gunn, Vicia Menziesii Sprengel (Fabaceae) Rediscovered, Its Taxonomic Relationships, Pacific Science (1979), Vol. 33, No. 1, Honolulu.

Medeiros, A., personal communication 1984.

Scott, M., unpublished monograph, 1984.

State of Hawaii, Department of Land and Natural Resources, Division of Forestry, A Botanical Reconnaissance of Malama-Ki Forest Reserve, Honolulu, 1981.

_____, A Vegetation Survey of the Halepuaa Forest Reserve, Honolulu, 1979.

_____, Statewide Non-game and Endangered Species Program, Job Report, 1984.

Environmental Protection Agency (EPA), Pollution Control Guidance for Geothermal Energy Development; National Technical Information Service, Springfield, Virginia, 1978.

United States, Department of the Interior, Fish and Wildlife Service, Alala Recovery Plan, Denver, 1982.

_____, Hawaiian Dark Rumped Petrel and Newell's Manx Shearwater Recovery Plan, Denver, 1983.

_____, Hawaii Forest Birds Recovery Plan, Denver, 1983.

_____, Nene Recovery Plan, Denver, 1983.

AIR QUALITY

Dames and Moore, Report Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii, Honolulu, 1984.

Houck, James E., Environmental Baseline Survey Kilauea East Rift Zone, Volume 1, Final Report (Study Period December 1982 through December 1983).

_____, Progress Report, January 1, 1984 through May 31, 1984, Environmental Baseline Survey, Year Two, Kilauea East Rift, Puna and Ka'u Districts, May 31, 1984,

State of Hawaii, Department of Health, Environmental Protection and Health Services Division, Proposed Revisions to Administrative Rules, Chapter 11-60, Air Pollution Control, covering Geothermal Activities, Draft dated 3/22/84.

NOISE

Dames and Moore, Report Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii, Honolulu, 1984.

State of Hawaii, Department of Planning and Economic Development, Geothermal Energy of Hawaii, Volume II, Honolulu, 1981.

_____, Geothermal Power Development in Hawaii, Volume 1, Honolulu, 1982.

True/Mid-Pacific Geothermal Venture in Coordination with Campbell Estate, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June, 1982.

STATE LAND USE DISTRICTS: COUNTY GENERAL PLANS, AND EXISTING LAND USES

Hawaii, County of, The General Plan, County of Hawaii, Hilo, January 1971.

Maui, County of, Maui County General Plan, December 28, 1977.

State of Hawaii, Department of Land and Natural Resources, Administrative Rules, Title 13, Chapter 2, and Subzone Maps.

_____, Board of Finding of Fact, Conclusions of Law and Decision and Order, in the Matter of the Conservation District Use Application of the Estate of James Campbell, CDUA No. HA-3/2/82-1463, Honolulu, February 25, 1983.

State of Hawaii, Land Use Commission, District Boundary Maps.

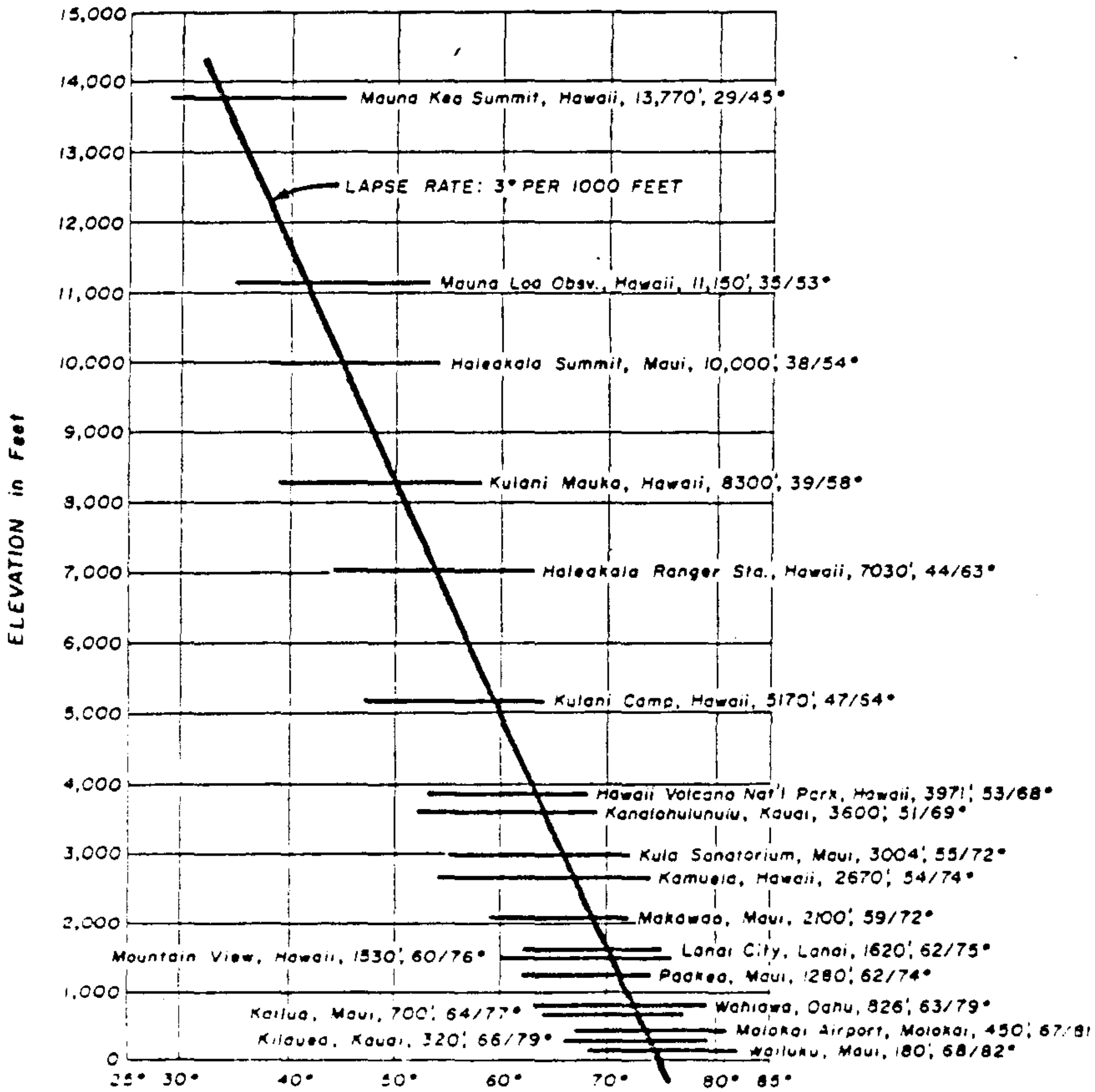

Figure 1. Decrease in Temperature at Various Elevations, Various Locations in the State of Hawaii.

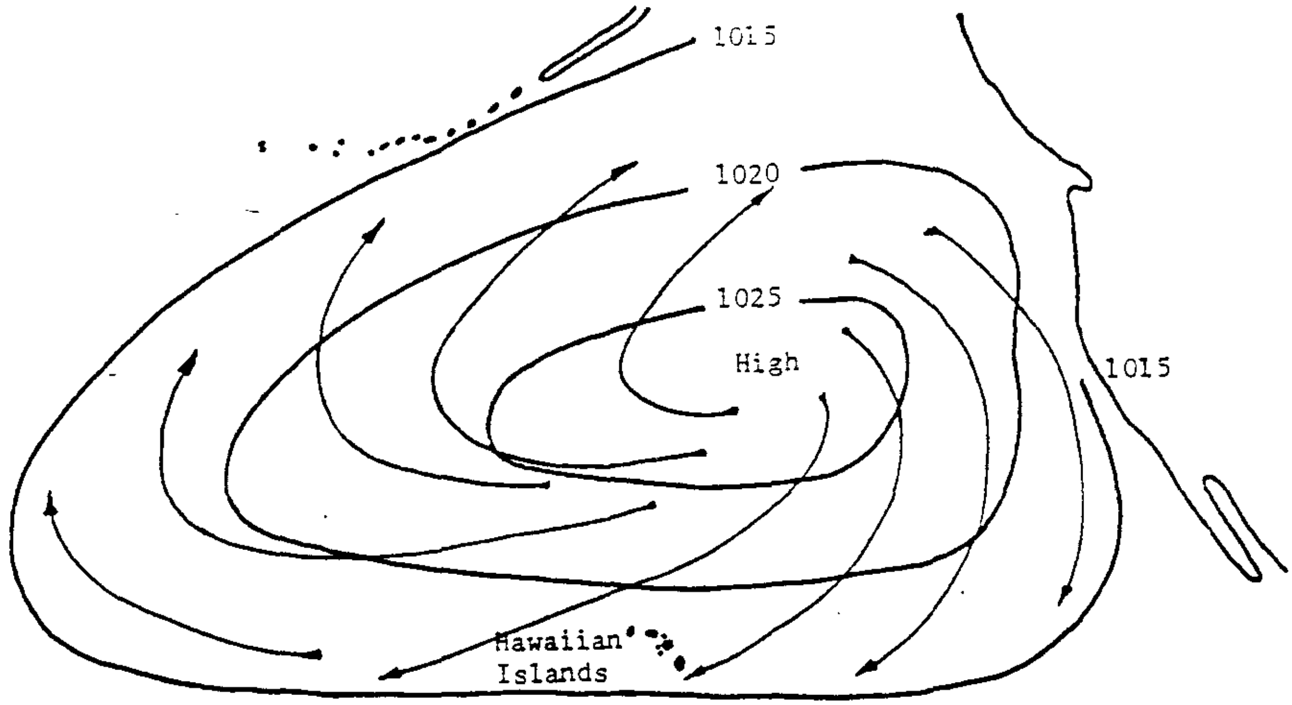

Figure 2a. Mean Pressure (millibars) and Wind Flow in the Eastern and Central North Pacific for July (summer).

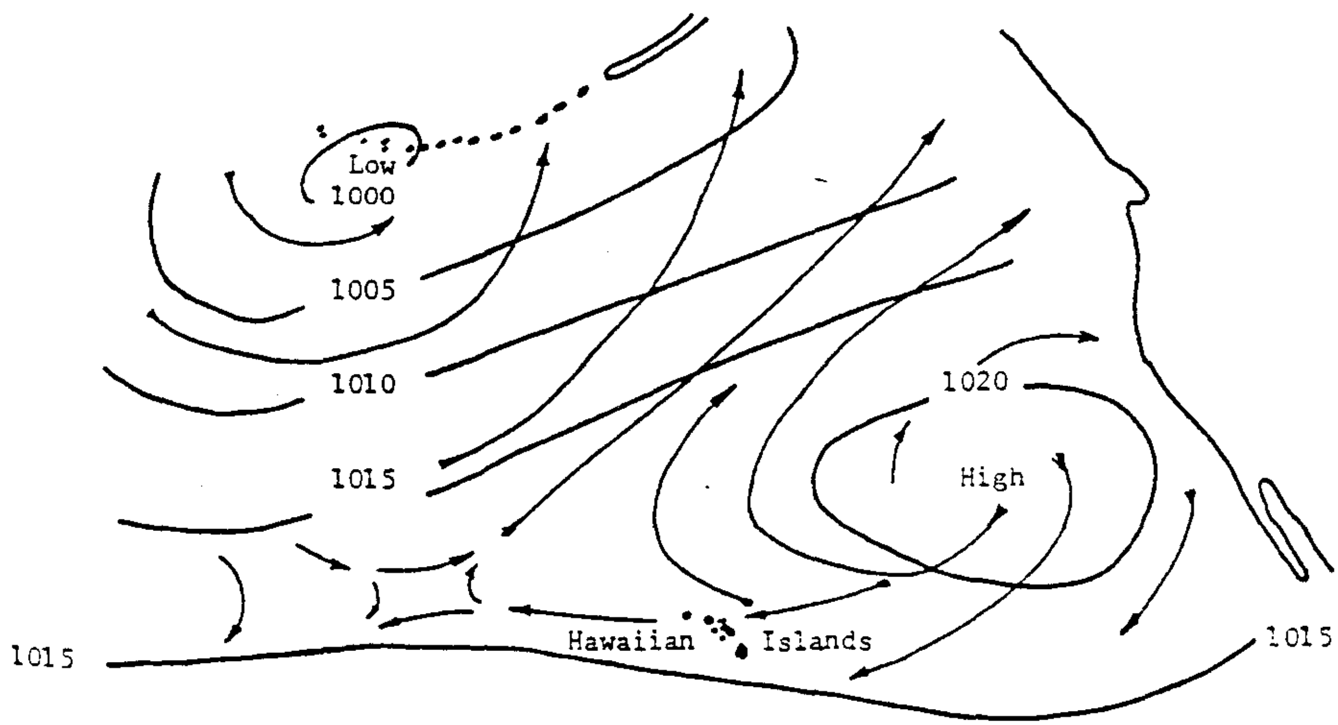

Figure 2b. Mean Pressure (millibars) and Wind Flow in the Eastern and Central North Pacific for January (winter).

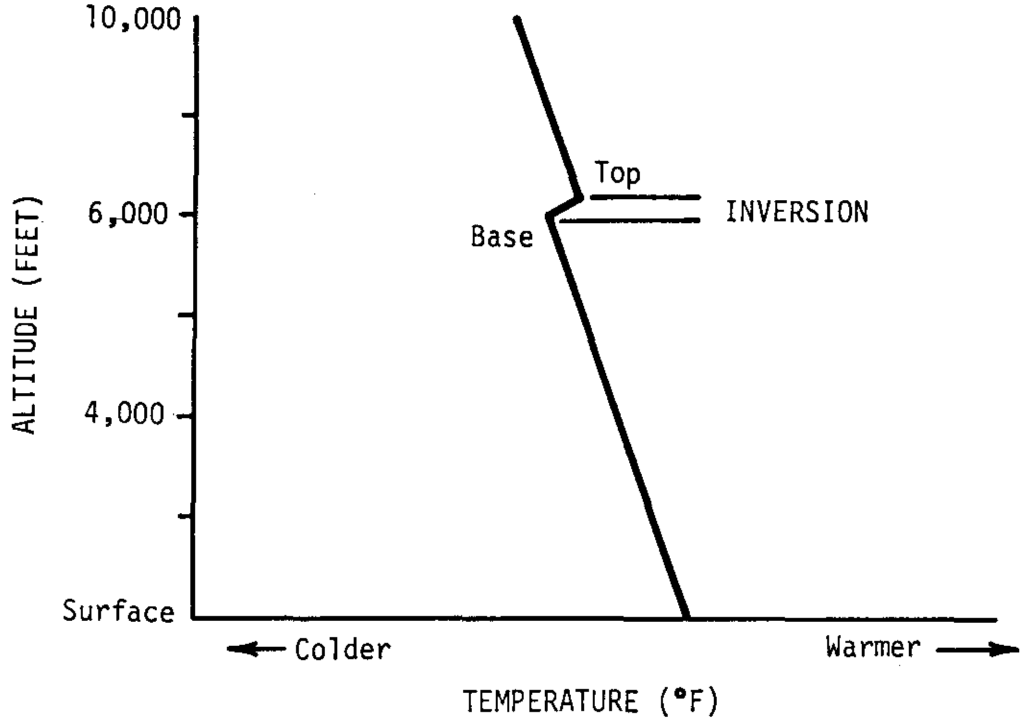

Figure 3a. Trade wind Temperature Inversion

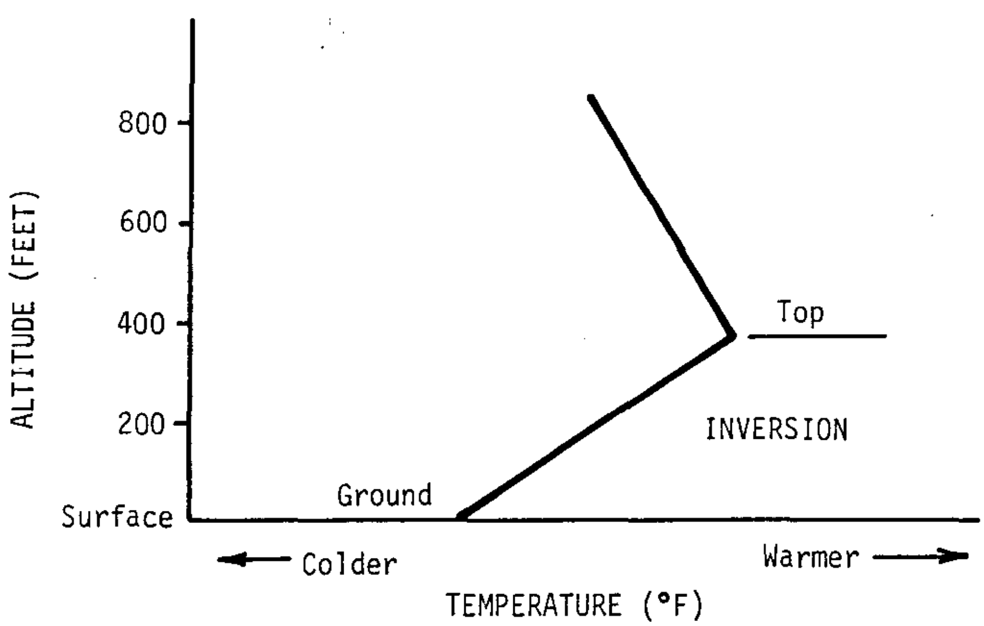

Figure 3b. Ground Temperature Inversion.

Figure 4. Endangered Native Flora

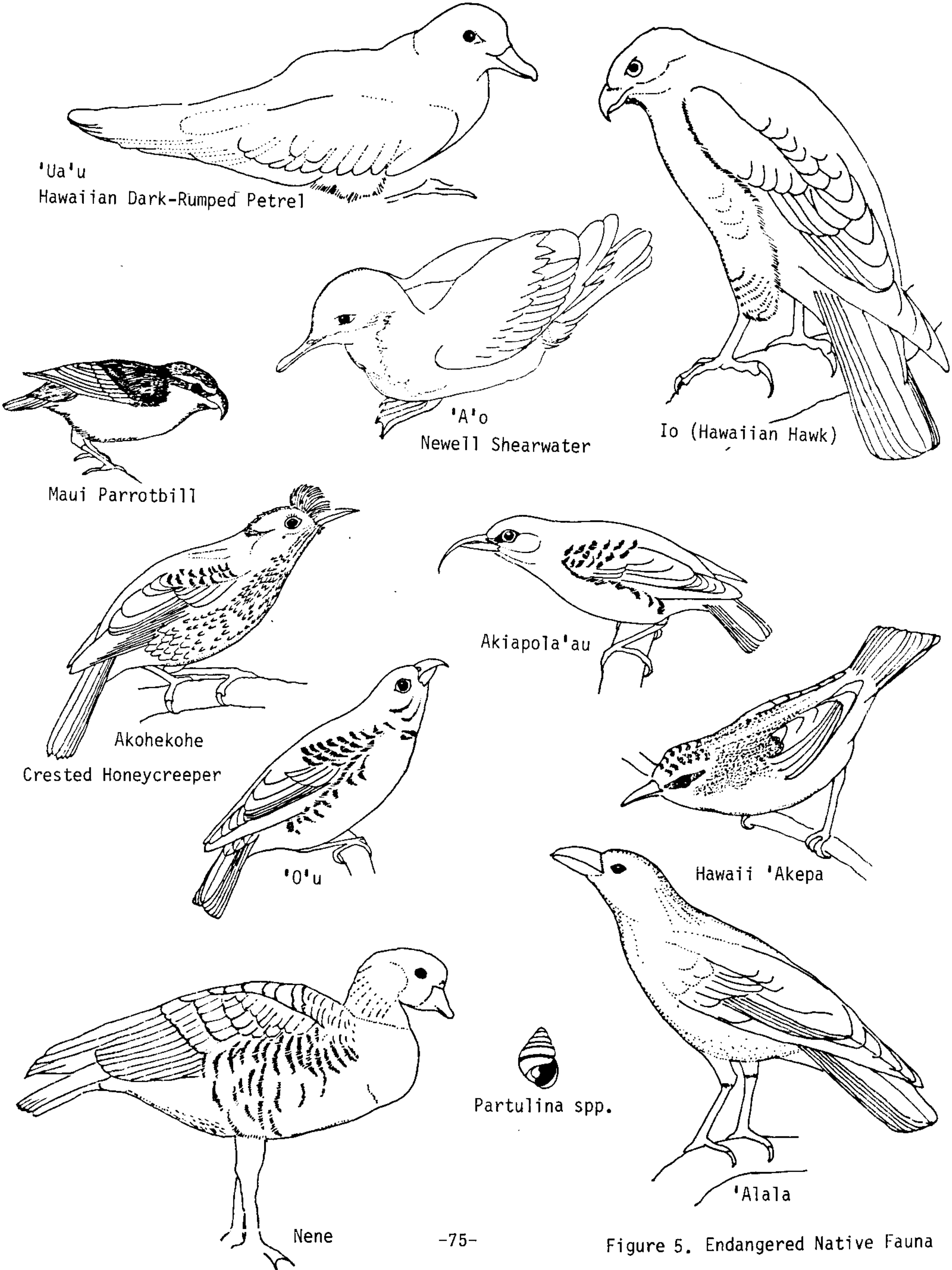

Figure 5. Endangered Native Fauna

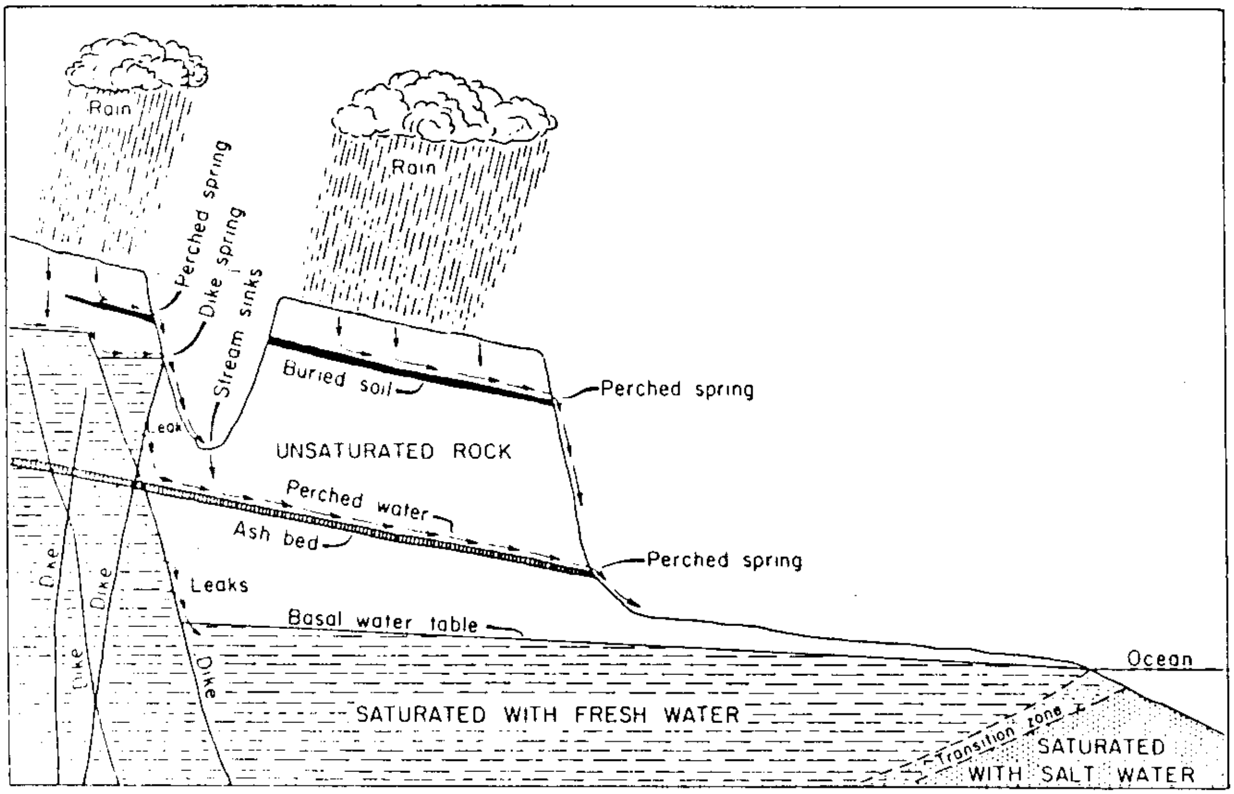

Figure 6. Diagram showing perched water, water confined between dikes, basal water, and pweched and basal springs (Modified after Stearns and Macdonald, 1946).

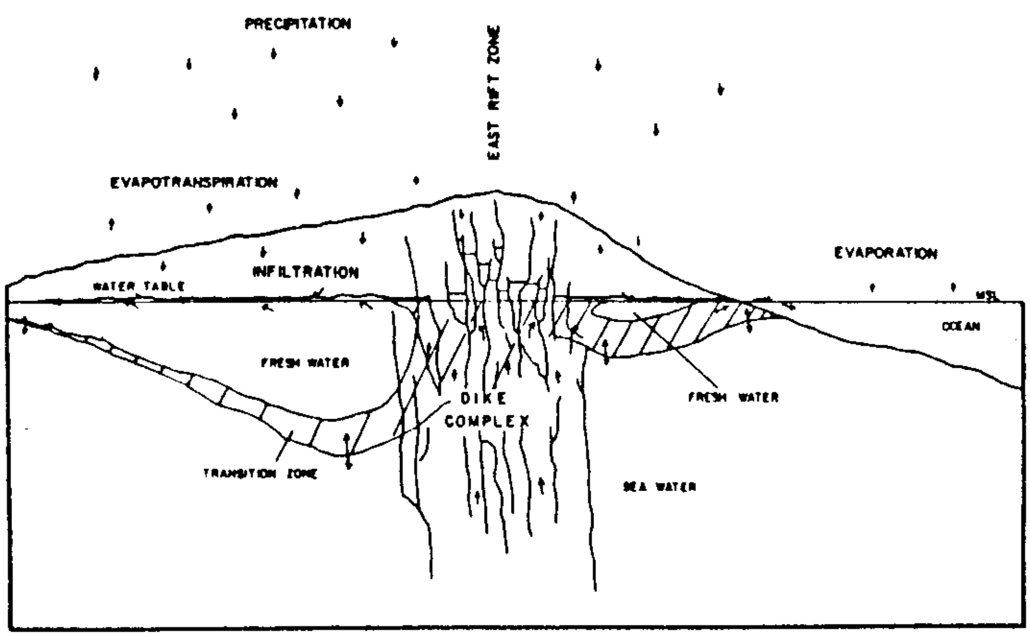

Figure 7. Diagrammatic north-south section through Puna District showing recharge, movement, discharge, storage and subsurface geology of ground water.

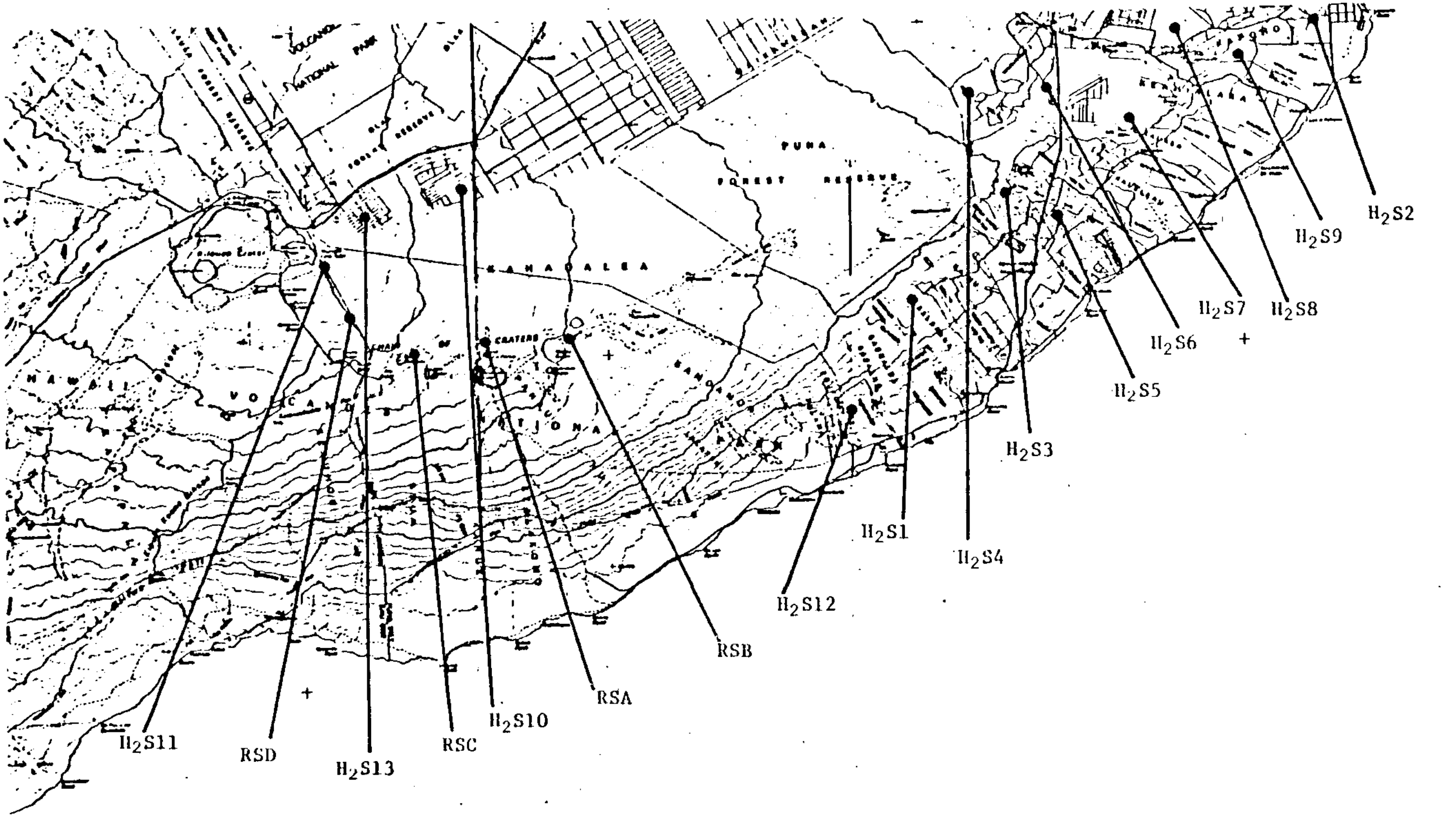

Figure 8. Approximate Loaction of Passive H_2S, Radon, and SFU Monitoring Stations (H_2S1-H_2S13 and RSA-RSD).
(SFU-stacked filter unit)
Source: Houck, 1984

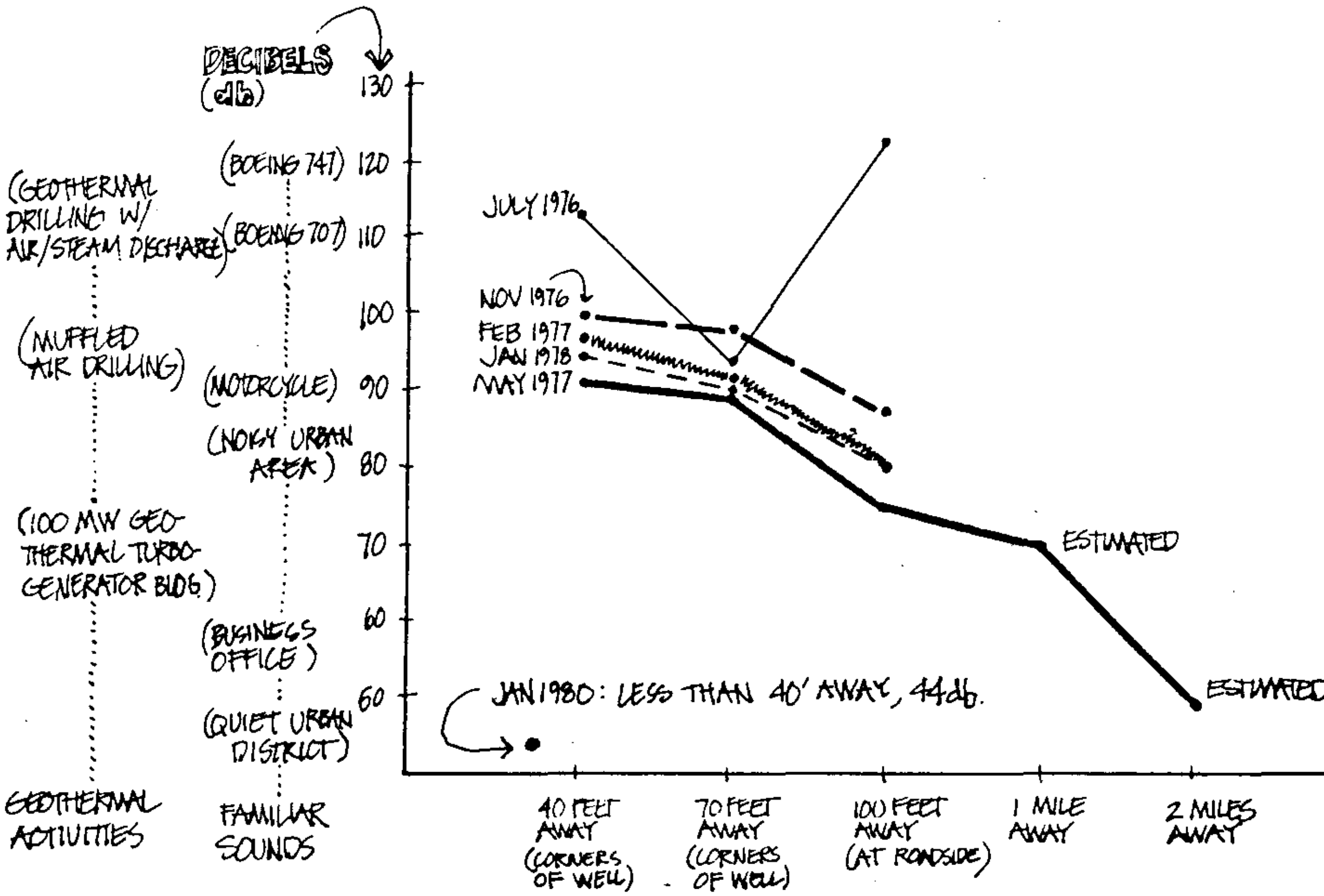

Figure 9. HGP-A Noise Characteristics
(Source: Yen and Iacofano, Geothermal Energy for Hawaii, A Prospectus, 1981).

APPENDIX A

Criteria for Vegetation Categorization from USFWS Mapping Code

and

Dominant Species Composition in Selected Rift Zones

Typical Mapping Code:

```
1 2     3  4    5    6
\ |____/ | ____/    /
 o3Me,2nt(W:tf,ns)sng
```

1. TREE CANOPY CROWN COVER

c = closed canopy, most crowns interlocking >60% cover
o = open canopy, some or no interlocking crowns 25-60% cover
s = scattered trees 5-25% cover
vs = very scattered trees <5% cover

2. TREE CANOPY HEIGHT

1 = low scrub trees, monopodial 2-5m tall
2 = scrub trees, moderate stature 5-10m tall
3 = tall stature trees >10m tall

3. TREE SPECIES COMPOSITION

a) Species name or association abbreviations

Ac = *Acacia koa* (koa)
Al = *Aleurites moluccana* (kukui)
Ep = *Euphorbia* sp. (ʻakoko)
Me = *Metrosideros polymorpha*
Mr = *Myrica faya* (Firetree)
My = *Myoporum sandwicensis* (naio)
nt = native tree association
Psc = *Psidium cattleianum* (strawberry guava, waiawi)
Sa = *Sapindus saponaria* (Manele; soapberry)
So = *Sophora chrysophylla* (mamane)
xt = introduced tree association

b) Species dominance

Species composition:*	Relative Dominance:
A	only A present
A-B	A and B codominant
A,B	A dominant, B subdominant
A,B-C	A dominant, B and C subdominant
A-B,C	A and B codominant, C subdominant
A-B-C	A,B,C codominant

*Substitute the appropriate species name or association abbreviation for the letters A, B, or C.

4. SPECIES ASSOCIATION TYPE

D = Dry habitat species
M = Mesic habitat species
W = Wet habitat species

5. UNDERSTORY SPECIES COMPOSITION

a) Species name or association abbreviation (Note: Species name abbreviations for trees may also be used if the understory is dominated by individuals of that species, less than 2m tall).

bg = structured bog
mf= matted ferns, Dicranopteris spp., Hicriopteris sp., Sticherous sp.
mg = mixed native-introduced grasses, sedges, or rushes
ng = native grasses
ns = native shrubs
Pm = Passiflora mollisima (banana poka)
tf = treeferns, Cibotium spp. (hapu´u)
xg = introduced grasses, sedges or rushes
xs = introduced shrubs
xx = bare ground (at least 25% of the area)

b) Species dominance (use same format as for tree species)

6. OTHER INFORMATION

bur = recently burned
clr = recently cleared or logged
fum = volcanic fume defoliation
msc = miscellaneous unit - mix of native and introduced species in low elevation areas
pio = pioneer vegetation, seral stage on recent lava flow
sng = many standing dead or defoliated trees

CATEGORY

1	c3, c2, or 3 w/tf, o2 w/tf (o3 if dry or mesic) and 90% or more native species by cover
2	co3, co2 and 75% native canopy (or simply 75% native canopy in non-ohia dominated dry and mesic communities)
2A	s vs 3 or 2, c o s vs 1, o2 w/mf and 50% or more native species by cover
3	Less than 50% native species or [3] Less than 50% ground cover [xx)

Hualalai

Category 1 contains three vegetation compositions. The first type consists of an open canopy of tall Metrosideros polymorpha (Ohia lehua) dominant to moderate size native trees with mesic habitat native shrubs forming the understory. Closed canopies of tall Acacia koa codominant with Metrosideros polymorpha comprise the second composition type. Moderate size native trees and an understory of mesic native shrubs and introduced grasses also occupy these areas. Codominant medium size Sophora chrysophylla (Mamane) and small native trees are scattered throughout the third composition type with dry habitat native shrubs and mixed grasses forming the underbrush.

Category 2A covers a large eastern portion of Hualalai. Dry habitat native shrubs scattered over bare ground comprises the largest section. An area stretching west to northeast of this section also contains very scattered Metrosideros polymorpha of moderate stature codominant with low standing native trees in addition to the underbrush described previously.

Category 2 generally consists of open and closed canopies of moderate to tall Metrosideros polymopha dominant with small to medium size native trees although some large areas also contain Acacia koa. Either dry habitat native shrubs, mesic native shrubs and introduced shrubs and grasses, or wet species of introduced and native shrubs and treeferns form the understory. Pioneer vegetation also grows in some areas.

Category 3 encompasses three compositions of vegetation. The largest section, lying in the western portion of Hualalai, contains scattered tall Metrosideros polymorpha codominant with medium size native trees and tall introduced trees. Mesic introduced grasses comprise the understory. East of this large section lies a plot of scattered, codominant tall Acacia koa, Metrosideros polymorpha, and medium size native trees. The understory consists of mesic introduced grasses. A smallplot of cleared land also exists.

Mauna Loa Southwest Rift

Category 1 contains open and closed canopies of tall Metrosideros polymorpha dominant to native scrub trees and shrubs. The species association type is generally mesic although wet and dry habitat species also exist.

Category 2A contains scattered Metrosideros polymorpha of low to moderate stature codominantly associated in some areas with low lying native trees. Dry habitat native shrubs scattered throughout bare areas are also present.

Category 2 is dominated by open and closed canopies of moderate to tall Metrosideros polymorpha interspersed with low to moderate size native trees and an understory of mesic to dry species of natural shrubs and introduced shrubs and grasses. Large plots of sub-dominant Acacia koa are located on the eastern areas while matted ferns occupy small areas of the Southern portion of the south west rift.

Category 3 contains large plots of bare land scattered with native shrubs. Scattered to very scattered Metrosideros polymorpha of moderate to tall stature occupy smaller areas dispersed throughout the southwest rift. Low to moderate size native trees codominate these areas, and introduced shrubs and grasses as well as native shrubs make up the underbrush. Tall Acacia koa can be found scattered in some areas, codominant with Ohia and native trees.

Mauna Loa East Rift (Upper Piihonua)

Category 1 consists predominantly of closed canopies of tall Metrosideros polymorpha with subdominant association of moderate size native trees. Small plots also contain tall Acacia koa trees. Mesic to wet habitat species of native shrubs and treeferns (Cibotium; hapu'u) comprise the underbrush.

Category 2A contains scattered Metrosideros polymorpha of various sizes codominantly associated in some area with native trees. Wet and mesic species of natural shrubs occupy most of the understory although one small plot contains dry habitat native shrubs and mixed grasses. Large segments of land also have defoliated trees and pioneer vegetation.

Category 2 generally contains open canopies of moderate to tall Metrosideros polymorpha standing alone with mesic species of native shrubs and pioneer vegetation occupying the understory. Some scattered areas also contain moderate size native trees. Beside the native shrubs, matted ferns and defoliated trees occupy small plots of wet areas while mixed grasses exist in some of the mesic and dry habitats.

Category 3 compositions are not found in this section.

Mauna Loa East Rift (Puu Ulaula)

Category 1 contains two types of vegetation compositions. The northern areas consist of closed and open canopies of Acacia koa codominant with Metrosideros polymorhpa. Native trees of moderate height and mesic habitat native shrubs and mixed grasses also occupy these areas. The southern plots contain open canopies of moderate size Metrosideros polymorhpa with an understory of dry habitat native shrubs.

Category 2A generally contains scattered to very scattered Metrosideros polymorpha of low to moderate height. In small areas, very scattered Sophora chrysophylla codominates with Metrosideros polymorpha. Scattered Acacia koa of moderate stature also occupy small plots codominating with native trees. Dry habitat, native shrubs occupy all areas while bare land covers at least 25% of these areas especially in the southern part of the rift zone. Mixed grasses also inhabitat small, scattered plots.

Category 2 compositions are scattered throughout this zone. These areas contain open canopies of moderate size Metrosideros polymorpha. Dry habitat native shrubs and mixed grasses make up the understory.

Category 3 which covers over 50% of this section consists of bare ground with scattered native shrubs.

Mauna Loa East Rift (Kulani)

Category 1 contains two major compositions of vegetation. Large areas, especially in the eastern parts, are dominated by open and closed canopies of tall Metrosideros polymorpha accompanied by moderate size native trees and a wet understory habitat of native shrubs and treeferns. Open and closed canopies of tall Acacia koa codominant with Metrosideros polymorha occupy other large areas. The understory contains either mesic native shrubs and treeferns. Moderate stature native trees also exist in these areas.

Category 2A consists of several different compositions. Most common are the open canopied and scattered Metrosideros polymorpha of low stature with an understory of dry habitat native shrubs scattered along bare ground. Western areas contain this combination. Pioneer vegetation also inhabits some of these areas. Small plots of codominant, scattered Acacia koa of moderate stature and native trees occupy the extreme northwest and southwest parts accompanied by an understory of dry habitat native shrubs and mixed grasses. A long, narrow band running north to northeast consists of bare ground with scattered mesic native shrubs and pioneer vegetation. To the extreme northeast lie several small plots consisting of scattered Metrosideros polymorpha condominant with moderate size native trees. Wet habitat native shrubs and defoliated trees form the understory. The eastern portion of this section features three areas containing introduced trees either dominant or codominant with Metrosideros polymorpha and native trees. Wet species of natural and introduced shrubs and matted ferns inhabit the understory of these areas.

Category 2 contains scattered and closed canopy coverings of moderate to tall Metrosideros polymorpha dominant or codomiant with smaller native trees. Dry to mesic habitats form the Western area underbrush consisting of native shrubs and mixed grasses. Wet species of native shrubs and treeferns inhabit the understory of the eastern plots. Several eastern areas also contain defoliated trees. Acacia koa exist in small plots in the southwest, and pioneer vegetation occupies southern and central plots in this region.

Category 3 consists of large areas of bare ground with scattered native shrubs in the extreme west. Scattered to very scattered Acacia koa of moderate to tall stature codominate smaller plots with native trees and Metrosideros polymorpha. Mesic to dry native shrubs and mixed grasses occupy the understory of these plots. Very scattered, tall Metrosideros dominate a recently cleared plot accompanied by mesic native shrub and introduced shrubs and grasses. A cleared plot and two other unmapped areas are also present.

APPENDIX B

Proposed Revisions to State of Hawaii, Department of Health Administrative Rules, Chapter 11-59, Ambient Air Quality Standards and Chapter 11-60, Air Pollution Control, covering Geothermal Activities.

Chapter 11-59 includes one-hour standard for H_2S of 100 ppb. Chapter 11-60 includes emission standards for geothermal wells and geothermal power plants and H_2S episode levels.

DRAFT—3/22/84

Amendments to Chapter 11-59, Administrative Rules.

1. §11-59-4, Administrative Rules, is amended to read as follows:

"§11-59-4 Ambient air quality standards. (a) [Interpretation.] The numercial ambient air quality standards below limit the time-averaged concentration of specified pollutants dispersed or suspended in the ambient air of the [state] State, but these standards do not in any manner authorize the significant deterioration of existing air quality in any portion of the [state] State.

(b) [Application.] Limiting concentrations specified for a twelve-month period or a calendar quarter shall not be exceeded. Limiting concentrations specified for one-hour, three-hour, eight-hour , and twenty-four-hour periods [less than twelve months] shall not be exceeded more than once in any twelve-month period.

(c) [Carbon monoxide.] In the ambient air the concentration of carbon monoxide measured by a reference method shall not exceed:

(1) An average value of ten milligrams per cubic meter of air during any one-hour period.

(2) An average value of five milligrams per cubic meter of air during any eight-hour period.

(d) [Nitrogen dioxide.] In the ambient air the average concentration of nitrogen dioxide measured by a reference method during any twelve-month period shall not exceed seventy micrograms per cubic meter of air.

(e) [Suspended particulate matter.] In the ambient air the concentration of suspended particulate matter measured by a reference method shall not exceed:

(1) [An average value] A geometric mean of [fifty-five] sixty micrograms per cubic meter of air during any twelve-month period.

(2) An average value of [100] one hundred fifty micrograms per cubic meter of air during any twenty-four-hour period.

(f) [Ozone.] In the ambient air the average concentration of ozone measured by a reference method during any one-hour period shall not exceed [100] one hundred micrograms per cubic meter of air.

(g) [Sulfur dioxide.] In the ambient air the average concentration of sulfur dioxide measured by a reference method shall not exceed:

(1) An average value of [twenty] eighty micrograms per cubic meter of air in any twelve-month period.

(2) An average value of [eighty] three hundred sixty-five micrograms per cubic meter of air in any twenty-four-hour period.

(3) An average value of [400] one thousand three hundred micrograms per cubic meter of air in any three-hour period.

(h) [Lead.] In the ambient air the average concentration of lead measured as elemental lead by a reference method during any calendar quarter shall not exceed 1.5 micrograms per cubic meter of air.

(i) In the ambient air, the concentration of hydrogen sulfide measured by a reference method shall not exceed one hundred thirty-nine micrograms per cubic meter of air in any one-hour period." [Eff. November 29, 1982; am] (Auth: 42 U.S.C. §7410, 7416; 40 C.F.R. Parts 50, 51; HRS §342-3, 342-22) (Imp: 42 U.S.C. §7407, 7409, 7410, 7416; 40 C.F.R. Parts 50, 51; HRS §342-22)

2. Material, except source notes, to be repealed is bracketed. New material is underscored.

3. Additions to update source notes to reflect these amendments are not underscored.

4. These rules shall take effect ten days after filing with the Office of the Lieutenant Governor.

I certify that the foregoing are copies of the rules, drafted in the Ramseyer format pursuant to the requirements of section 91-4.1, Hawaii Revised Statutes, which were adopted on ____________________, and filed with the Office of the Lieutenant Governor.

CHARLES G. CLARK
Director of Health

APPROVED AS TO FORM:

Deputy Attorney General

Amendments to Chapter 11-60, Administrative Rules.

1. Chapter 11-60, Administrative Rules, is amended by adding a new section, 11-60-23.1, to read as follows:

"§11-60-23.1 Geothermal wells. (a) A well as used in this section and section 11-60-23.2 means any well which obtains, or is designed to obtain, a geothermal resource.

(b) Prior to a well being part of a distribution system which supplies a geothermal resource to a power plant which has commenced using the geothermal resource, emissions from the well shall not be in excess of five pounds of particulates, and five pounds of hydrogen sulfide, per one hundred pounds of each respective pollutant in the geothermal resource.

(c) After a well is part of a distribution system which supplies a geothermal resource to a power plant which has commenced using the geothermal resource, emissions from the well of hydrogen sulfide shall not be in excess of two pounds per one hundred pounds of hydrogen sulfide in the geothermal resource.

(d) The owner or operator of a well shall obtain an authority to construct and a permit to operate as follows:

(1) Prior to commencement of well construction, an authority to construct shall be obtained in conformance with subchapter 3, and if applicable, subchapter 4.

(2) Prior to a well being part of a distribution system which supplies geothermal resource to a power plant which has commenced using the geothermal resource, a permit to operate shall be obtained in conformance with subchapter 3.

(e) This section shall be in effect immediately for any well which has not begun actual construction before the effective date of this section. An existing well or one which has begun actual construction before the effective date of this section shall be in compliance with this section by December 31, 1986." [Eff.] (Auth: HRS §§342-3, 342-22, 342-23) (Imp: §§342-3, 342-22, 342-23)

2. Chapter 11-60, Administrative Rules, is amended by adding a new section 11-60-23.2 to read as follows:

"§11-60-23.2 Geothermal power plants. (a) A power plant as used in this section and section 11-60-23.1 means any power plant which uses or is designed to use, a geothermal resource. A power plant as defined shall not include the well(s) supplying the geothermal resource to the power plant.

(b) Hydrogen sulfide emissions from a power plant shall not exceed two pounds per one hundred pounds of hydrogen sulfide in the incoming geothermal resource.

(c) The maximum allowable increase in hydrogen sulfide concentration in the ambient air above natural background level shall be thirty-five ug/m^3 as a one-hour average, considering all stationary sources except geothermal wells in the area affected by the power plant applying for an authority to construct. The maximum allowable increase may be exceeded once per twelve-month period at any one location.

(d) No power plant shall consume any part of the thirty-five ug/m^3 maximum allowable increase until an authority to construct application is certified complete by the director.

(e) The owner or operator of a power plant shall obtain an authority to construct and a permit to operate in conformance with subchapter 3, and if applicable, subchapter 4.

(f) This section shall be in effect immediately for any power plant which has not begun actual construction before the effective date of this section. An existing power plant or one which has begun actual construction before the effective date of this section shall be in compliance with this section by December 31, 1986." [Eff.] (Auth: HRS §§342-3, 342-22, 342-23) (Imp: HRS §§342-3, 342-22, 342-23)

3. §11-60-35, Administrative Rules, is amended and renumbered to read as follows:

"[§11-60-35] §11-60-19 Prevention of air pollution emergency episodes. (a) Notwithstanding any other provision of [the air pollution control regulations, this episode regulation] this chapter, this section is designed to prevent the excessive buildup of air contaminants during air pollution episodes, thereby preventing the occurrence of any emergency due to the effects of these contaminants on the public health.

(b) [Episode criteria.] Conditions justifying the proclamation of an air pollution alert, air pollution warning, or air pollution emergency shall be deemed to exist whenever the director determines that the accumulation of air contaminants in any place is attaining or has attained levels which could, if such levels are sustained or exceeded, lead to a threat to the health of the public. In making this determination, the director [will] shall be guided by the [following] criteria[:] set forth in subsections (c) to (g).

[(1)] (c) "Air pollution forecast": An internal watch by the department shall be actuated by a national weather service advisory that atmospheric stagnation advisory is in effect or the equivalent local forecast of stagnant atmospheric conditions.

[(2)] (d) "Alert": The alert level is that concentration of pollutants at which first stage control action is to begin. An alert [will] shall be declared when any one of the following levels is reached:

[(A)] (1) SO_2 - [800] eight hundred ug/m^3 (0.3 ppm), [24-] twenty-four hour average;

[(B)] (2) Particulate matter - [3.0 COHs or 375] three hundred seventy-five ug/m^3, [24-] twenty-four hour average;

[(C)] (3) SO_2 and particulate matter combined - [product of SO_2, ppm, 24-hour average and COHs equal to 0.2 or] product of SO_2, ug/m^3, [24-] twenty-four hour average and particulate matter, ug/m^3, [24-] twenty-four hour average equal to $65x10^3$;

[(D)] (4) CO - [17] seventeen mg/m^3 ([15] fifteen ppm), [8-] eight hour average;

[(E)] (5) [Oxidant] Ozone - [200] four hundred ug/m^3 ([0.1] 0.2 ppm), [1-] one hour average;

[(F)] (6) NO_2 - [1,130] one thousand one hundred thirty ug/m^3 (0.6 ppm), [1-] one hour average; [282] two hundred eight-two ug/m^3 (0.15 ppm), [24-] twenty-four hour average; or

(7) H_2S - one hundred thirty-nine ug/m^3 (0.10 ppm), one hour average;

and meteorological conditions are such that this condition can be expected to continue for twelve or more hours.

[(3)] (e) "Warning": The warning level indicates that air quality is continuing to degrade and that additional abatement actions are necessary. A warning [will] shall be declared when any one of the following levels is reached:

[(A)] (1) SO_2 - [1,600] one thousand six hundred ug/m^3 (0.6 ppm), [24-] twenty-four hour average;

[(B)] (2) Particulate matter - [5.0 COHs or 625] six hundred twenty-five ug/m^3, [24-] twenty-four hour average;

[(C)] (3) SO_2 and particulate matter combined - [product of SO_2, ppm, 24-hour average and COHs equal to 0.8 or] product of SO_2, ug/m^3, [24-] twenty-four hour average and particulate matter, ug/m^3, [24-] twenty-four hour average equal to 261x10^3;

[(D)] (4) CO - [34] thirty-four mg/m^3 (30 ppm), [8-] eight hour average;

[(E)] (5) [Oxidant] Ozone - [800] eight hundred ug/m^3 (0.4 ppm), [1-] one hour average;

[(F)] (6) NO_2 - [2,260] two thousand two hundred sixty ug/m^3 (1.2 ppm), [1-] one hour average; [565] five hundred sixty-five ug/m^3 (0.3 ppm), [24-] twenty-four hour average; or

(7) H_2S - one thousand three hundred ninety ug/m^3 (1.00 ppm), one hour average;

and meteorological conditions are such that this condition can be expected to continue for twelve or more hours.

[(4)] (f) "Emergency": The emergency level is reached when the warning level for a pollutant has been exceeded and:

[(A)] (1) The concentrations of the pollutant are continuing to increase[,]; or

[(B)] (2) The director determines that, because of meteorological or other facts, the concentrations will continue to increase[,]; or

[(C)] (3) When any one of the following levels is reached:

[(i)] (A) SO_2 - [2,100] two thousand one hundred ug/m^3 (0.8 ppm), [24-] twenty-four hour average;

[(ii)] (B) Particulate matter - [7.0 COHs or 875] eight hundred seventy-five ug/m^3, [24-] twenty-four hour average;

[(iii)] (C) SO_2 and particulate matter combined—[product of SO_2, ppm, 24-hour average and COHs equal to 1.2 or] product of SO_2, ug/m^3, [24-] twenty-four hour average and particulate matter, ug/m^3, [24-] twenty-four hour average equal to 393x10^3;

[(iv)] (D) CO - [46] forty-six mg/m^3 ([40] forty ppm), [8-] eight hour average;

[(v)] (E) [Oxidant] Ozone - [1,200] one thousand ug/m^3 (0.6 ppm), [1-] one hour average;

[(vi)] (F) NO_2 - [3,000] three thousand ug/m^3 (1.6 ppm), one [1-] hour average; [750] seven hundred fifty ug/m^3 (0.4 ppm), [24-] twenty-four hour average; or

(G) H_2S - thirteen thousand nine hundred ug/m^3 (10.0 ppm), one hour average.

[(5)] (g) "Termination": Once declared, any [status] episode level reached by application of these criteria [Will[shall remain in effect until the criteria for that level are no longer met. At [such] that time, the next lower [status] episode level [will] shall be assumed." [Eff. November 29, 1982; am and ren S11-60-19] (Auth: HRS SS342-3, 342-22; 42 U.S.C. S7407, 7410, 7416; 40 C.F.R. Parts 50, 51, 52) (Imp: HRS SS342-3, 342-9, 342-22; 42 U.S.C. SS7407, 7410, 7416; 40 C.F.R. Parts 50, 51, 52)

2. Material, except source notes, to be replaced is bracketed. New material is underscored.

3. Additions to update source notes to reflect these amendments are not underscored.

4. These amendments to Chapter 11-60, Administrative Rules, shall take effect ten days after filing with the Office of the Lieutenant Governor.

I certify that the foregoing are copies of the rules, drafted in the Ramseyer format pursuant to the requirements of section 91-4.1, Hawaii Revised Statutes, which were adopted on ________________________ and filed with the Office of the Lieutenant Governor.

____

CHARLES G. CLARK

Director of Health

APPROVED AS TO FORM:

____

Deputy Attorney General

APPENDIX C

ARCHAEOLOGICAL LITERATURE SEARCH

Kilauea East Rift Zone, (True/Mid Pacific Geothermal Venture, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June, 1082, prepared by Tommy Holmes, April 1982).

Archaeological Literature Research
Tommy Holmes
April 1982

The following is a brief summary of the findings of a documentary literature search on the ahupuaa of Kahauale'a in the Puna District of the island of Hawaii. Attention is given to the entirety of the ahupuaa, though the emphasis is on the mauka portions from about 1,500' to 3,800' elevation, or roughly three miles inland to the northern terminus of the ahupuaa, just below Kilauea Iki. The present document consists of excerpts from a longer report entitled "A Preliminary Report on the Early History and Archaeology of Kahauale'a, Puna, Hawaii" prepared by Tommy Holmes for the Estate of James Campbell.

TRAILS

In Puna, where canoe landing and launching sites were very few and extremely dangerous, trails held special significance. Given terrain that was alternately rugged lava and thick jungle, Puna residents had no choice but to develop a good trail system over which a great part of trade, communications and transportation occurred.

Several old trails were known to have either passed through Kahauale'a ahupuaa or started at some point outside the area or at the coast and penetrated into Kahauale'a for a certain distance. At least four of these trails traversed Kahauale'a in a rough east-west direction. The trail most makai followed the contour of the coastline just a few feet from the ocean.

A second ancient trail called on maps today the Kalapana or Volcano-Kalapana Trail crossed Kahauale'a a little more than half a mile inland. This was apparently the preferred route in traveling from Puna to the Volcano area (although there were other routes, e.g. Ellis' path).

Coming up on this same trail from Puna, one could continue on to the Volcano or branch off to the right just below Makaopuhi crater to re-enter and recross Kahauale'a at about the 2,700-ft. level. About ten miles inland, this ancient trail, called the Glenwood-Makaopuhi Trail on today's maps, took one through to Keeau and Ola'a and eventually back to Hilo.

The fourth ancient trail, used by Capt. Wilkes' party in 1840, apparently began just to the east of Makaopuhi and traversed Kahauale'a at about the 2,200-ft elevation, passed just north of Kalalua crater and continued down the rift zone.

Hudson also mentions an "old trail across the lava flow south of Makaoiki [a heiau in Kahauale'a about a mile inland].

Makai-mauka trails are shown on U.S. Geological Survey maps compiled in 1912 and 1922. A single trail begins at the coast on the border of Kahauale'a and Kapaahu ahupuaa and runs inland for about three miles in a roughly northerly direction before it branches. The major branch, called the Kapaahu trail, continues into Kahauale'a till about the 1,500-ft. elevation where on the map it terminates. The branch trail fairly closely parallels the Kapaahu trail before it too seems to end at about the same elevation. Most likely one or both trails might have at one time gone considerably further inland serving bird-catchers, canoe-makers, upland farmers, forest product gatherers, travelers, etc. Chester Lyman reported in 1846, taking a trail that appears to have started at the coastal village of Kahauale'a and continued almost due north into the interior of Kahauale'a and back to Hilo.

Indeed there were probably a number of coast-inland trails that accessed the archaeological sites, reported as far as three miles or more inland on neighboring ahupuaa of Kahauale'a. That some would have gone inland up the Kahauale'a corridor is very likely.

The manufacture and export of pulu, the soft, wooly substance found at the base of hapuu ferns, was, according to Thrum, an important industry from 1851 to 1884. Most pulu came from an extensive tract of fern and ohia forest in the Kilauea vicinity. Brigham noted that, "In the early sixties [1860's] the business of picking and packing pulu had become so important that trails cut by the many natives thus employed opened the crater country far more than ever before."

SITES

As mentioned previously, most known sites in Kahauale'a are found quite close to the shore. The most seaward is a canoe ladder site, one of several along the cliff-bound coast of Puna.

Considering the numerous ahupuaa that make up the Puna District, the reported presence of three heiaus in Kahauale'a alone, where many other Puna ahupuaa, often more populous, had none is of some interest.

Located within a couple of hundred yards from the sea adjoining Waikupanaha pond is what Hudson calls Waiaka heiau.

A second heiau, called Punaluu, unquestionably in Kahauale'a, was quite large and complex.

The other reported heiau in Kahauale'a, called by Thrum and Hudson, Makaoiki, was located "about a mile inland from Kupaahu village...in the middle of an aa flow. The adjacent graves are pits sunk in the surface of the flow. Hudson also notes a "former burial cave, a short distance south of site 179 [Makaoiki]. The cave is known as "Kalua Makini".

In the land of Pulama (on old maps the ahupuaa bordering Kahauale'a to the west) Hudson reports a heiau, Makaiwa, three miles from the sea. Thrum calls it an "ipuolono" or agricultural-type heiau. Early Hawaiian scholar S. M. Kamakau says such "ipuolono heiaus... temples, or more properly household shrines, were to foster food.

Mention of this heiau, though it is not in Kahauale'a, is made here for two reasons.

First: The location of Makaiwa heiau three miles inland, coupled with the location of several other heiau in the southwest Puna area that Hudson places nearly as far inland, strongly suggest that there was significant activity in Kahauale'a and nearby ahupuaa well inland of what was expected when the present study was initiated.

Second: At three miles from shore, Makaiwa heiau and attendant sites are almost to the furthest inland reaches of Pulama which is bounded by a dog-leg of Kahauale'a to the north. In fact, Makaiwa heiau and the other sites are located just a few hundred yards outside Kahauale'a. Hudson notes that in support of the classification of Makaiwa as an "ipuolono" heiau are "the many old agricultural workings found nearby [that] indicate that the purpose of the heiau was to protect and fructify the crops". He goes on to say "In the neighborhood of Makaiwa heiau are a number of platforms, house sites, terraces, pens, and walls.

To extrapolate that there might be sites or site complexes a few hundred yards away in Kahauale'a, at the same distance or more inland, is not unreasonable.

UPLAND SITES

It is, in fact, at the elevation of Makaiwa heiau and accompanying sites that Jim Jacobi [personal communication 1982] reported during a bird survey done in the late 1970's, seeing a number of sites. His recall is that these sites were about 1½ to 2 miles below Kalalua Crater situating them in Kahauale'a at about 1200'-1500' elevation, 3½ to 4 miles inland, and by crude calculation relatively near the Makaiwa heiau complex.

Moving up in elevation Mr. Jacobi also recalled seeing a scattering of apparent sites immediately mauka of Kalalua Crater. He also reported part of the ancient trail that Wilkes' party used as still being in evidence in this Kalalua vicinity. Lastly, he recalls seeing certain cultigens, particularly the ti plant, growing in the Kalalua area, further suggesting one time agricultural activity.

Handy recorded information regarding the extent of inland agricultural activity in western Puna in 1935, when there were still individuals living who were familiar with Puna's early history. According to his informants, there is very strong evidence for agricultural activities well inland in Kahauale'a. "Land northeast of Kapa'ahu [that, according to Handy's informants]...used to be covered with plantations" is adjacent and virtually identical in terms of terrain and vegetative cover to the lower mauka portions of Kahauale'a. The description of Kaho'onoho at least 2.5 miles into Kahauale'a's forested interior, and Wala'ohia, also considerably inland, as "the two great forest planting areas in Kahauale'a" rather pointedly suggests upland agricultural activity in Kahauale'a. Similarly, the Kupahua homesteading area, upper Kalapana and upper Kaimu are all three to four miles inland, quite close to Kahauale'a, and similar in nature of terrain and vegetation. Supporting Handy's observations on agricultural activity in western Puna are other references, some already noted and more below.

Two other references, if calculations and assumptions are correct, would place agricultural activities well into Kahauale'a's interior. An "extensive upland taro patch" referred to in 1841 by Capt. Charles Wilkes, head of the U.S. Exploring Expedition, was apparently in Kahauale'a, probably at about 2,000' to 2,200' elevation.

Chester Lyman, who traveled through Puna in 1846 with Rev. Coan, also reports a plantation about five miles inland in Kahauale'a.

At 10 miles he makes note of "a small grass shanty" that could have been a temporary abode for travelers, farmers, or forest product gatherers.

At Panau, a small village near Kahauale'a at about 2,500' elevation and just below Napau crater, there was also agricultural activity. Rev. William Ellis, traveling in 1823 through what appears to be the Panau area, says "The natives ran to a spot in the neighborhood, that had formerly been a plantation, and brought a number of pieces of sugar-cane..."

That there was a permanent village this far inland (about 5 miles) and within minutes of walking time from Kahauale'a, would lead one to suspect that permanent and temporary inhabitants of Panau made regular trips into Kahauale'a for various forest products.

Wilkes, in 1841, says of Panau that "Here many canoes are built and transported to the sea, the trees in the vicinity being large and well adapted to this purpose. What this and other canoe related references suggest is that logging koa trees for canoe hulls and procuring wood for other canoe parts might well have been another inland forest activity within Kahauale'a.

The pre- and early post-contact native forest regime of mauka Kahauale'a, with its extensive ohia canopy provided a near ideal habitat for many of the birds sought after by bird-catchers, kia manu. Feathers from certain birds were made into the highly-prized feather work artifacts of the ali'i - capes, cloaks, helmets, kahili, etc.

Early Hawaiian scholar, N. B. Emerson writing in 1895 about bird-catching considered Kilauea, Puna, and upper Hilo amongst the most desirable bird-catching areas in the islands, implying that Kahauale'a by its location (in Puna and contiguous with Kilauea) and type of vegetative, cover was ideal bird country.

Hudson, while not mentioning Panau by name, says that "a few sites were also found in the upland forest region around Makaopuhi and Napau craters at an elevation of about 2,700 feet 6 miles from the sea". Unfortunately, he does not elaborate further on just where the sites were located or what type they were. He does, though, go on to describe other suspected and known sites, including a pulu factory, and possible religious and habitation sites in the Panau village vicinity.

These sites would all be very close to the border of Kahauale'a. Ellis mentions in 1823 a heiau to Pele near Kilauea-iki which is all but contiguous with the northern-most terminus of Kahauale'a.

Whatever the exact location of these other inland sites the point is firmly made. There was a variety of activities, such as canoe building, agriculture, and birdcatching, in the greater volcano area and regular travel through it along several trails. Kahauale'a mauka was an integral part of the physical and resource bounds of these early inhabitants, temporary workers, and transients. In summary, it would not be unreasonable to expect that there are archaeological sites in the mauka portions of Kahauale'a.

APPENDIX D

ARCHAEOLOGICAL SITES IN GEOTHERMAL RIFT ZONES

Source: Department of Land and Natural Resources, Division of State Parks, Historic Site Section maps and site records as of July, 1984.

Site Number	Description
KILAUEA EAST RIFT ZONE	
10-52-5508	Old Volcano House #42 (National Register)
10-60-7371	Kapapala Ranch Manager's House
10-60-7372	Kapapala Ranch Complex
10-68-7361	Punaluu Landing and Railroad Terminal
10-69-7362	Pahala District
10-68-7370	Site of former Opukahaia House
19-53-7414	Volcano Residential District
10-68-4310	Wailau Complex 1
10-68-4368	Koloa Complex
10-68-4370	Luu Complex
50-10-46-4295	Pualaa Complex II
10-45-7387	Puulaa Congregational Church
50-10-46-4250	Kings Cairns
50-10-46-4251	Kumakahi Grave Sites (State Register)
50-10-46-7492	Lyman Marker
50-10-46-2501	Kapoho Petroglyphs (State Register)
50-10-46-4278	Kahuwai Village Complex
50-10-55-7388	Pahoa District
50-10-46-2500	Kukii Helau
50-10-46-4294	Pualaa Complex I
50-10-46-4254	Kapoho Pt. Platform
50-10-46-4255	S. Kapoho Pt. Complex
50-10-46-2529	MacKenzie Petrogyph Filed (State Register)

MAUNA LOA SOUTHWEST RIFT

10-73-7353	Kahuku Ranch House
10-73-7357	Captain Robert Brown Marker
10-66-7313	Tobacco Barn
10-66-7314	Kona House #10
10-66-7315	Kona House #11
10-66-7316	Hoopuloa Church Site
10-66-7317	I.M. Littorin House
10-66-7318	Kona House #12
10-66-7311	Tobacco Barn & Slaughter House
10-66-7312	McWayne House
10-66-7365	C.Q. Yee Hop Lumber Mills
10-71-2162	Lava Tube Complex (State Register)
10-72-3700	Kalanamauna Upland Complex (State Register)
10-73-7364	Kamoa Homestead House
10-72-2161	Keawaiki Complex (State Register)

MAUNA LOA EAST RIFT ZONE-no sites indicated

HUALALAI-no sites indicated

HALEAKALA EAST

50-50-13-1078	Kalapuni Ko'a (State Register)
50-50-13-1482	Ka'uiki Hill
50-50-13-1485	Kawaipapa Complex (State Register)
50-50-13-107	Waikaloa Platform (State Register)
50-50-13-109	Kauleiula Heiau (State Register)

50-50-13-110	Kauleilepo Heiau (State Register)
50-50-13-1487	Noa Fishponds (State Register)
50-50-13-117	Koahaepali Heiau
50-50-13-522	Aleamai Enclosure (State Register)
50-50-13-573	Ka Iwi O Pele Complex
50-50-13-1491	Kainalimu Enclosure (State Register)

HALEAKALA SOUTHWEST RIFT ZONE

50-50-14-192	Papanuiokane Heiau
50-50-14-1017	Kalua O Lapa Burial Cave
50-50-14-1018	Maonakala Village Complex (State Register)
50-50-14-1021	Poo Kanaka Stone (State Register)
50-50-14-1009	Puu Naio Cave (State Register)
50-50-14-1385	La Perouse Archaeological District (State Register)
50-50-14-1006	Kanaio Mauka Complex (State Register)
50-50-14-1019	Paako Point Ko'a
50-50-15-572	Hoapili Trial (State Register, National Register nomination)
50-50-14-1234	Kaipolohua Cave (State Register)
50-50-14-1235	Cave of Seven Coffins (State Register)

APPENDIX E

VISUAL IMPACT ANALYSIS

(True/Mid Pacific Geothermal Venture, Revised Environmental Impact Statement for the Kahaualea Geothermal Project, June 1982).

VISUAL IMPACTS

Concern has been raised about the possible adverse impact that the power plants might have on the vistas within the Hawaii Volcanoes National Park (HVNP). The EIS addresses this issue in Sections 5 and 6. To further document the very minimal visual impacts of the project facilities, an area terrain analysis was made to determine locations outside of the property from which the facilities could be seen. Figure 1 shows the "observer locations" around the Park used in the terrain analysis. Figures 2 through 7 represent visual perspectives from selected observer stations.

Points were chosen at 100-foot elevation increments along the approach road to the Park (Volcano Highway) as well as the nearby public roads in the Park. For each of these points, a view line was calculated from an observer (whose eyes were considered to be 10 feet above the road) to the top of an 80-foot high power plant (A, B, C or D) or a 65-foot high power plant (E). In almost all cases, this view line went below the surface of the ground between the observer and the power plant. Two exceptions to these results occur (1) in the immediate vicinity of the entrance road to the dump site (transfer station) along the Volcano Highway about 2.5 miles east of the Volcano community (Station 7) and (2) a 1,500-foot section of the Chain of Craters Road just as it starts over the Kalanaokuaiki Pali near the turn-off to the Ainahou Ranch where a view corridor is present in which the upper 20 feet (more or less) of a power plant at Site E could be seen.

View lines were also calculated for points along the Napau Crater Trail as well as for other points north of this trail between the trail head and Puu Kamoamoa. The power plants would be visible from about half of the length of this trail as well as from many points in the barren lava fields of the area. Based upon this analysis as well as visual inspection of air photos and maps, it is estimated that one or more power plants may be visible from about 30 percent of the rift zone area north of the trail in this region. To the south of the Napau Trail, the power plants cannot be seen except from a few high points due to the abrupt change of regional slope. Even when the power plants are visible, they are at distances of one to six miles and thus they would not be significant intrusive features with proper design and construction considerations. In no case are they expected to be seen as a silhouette on the horizon, but instead, they would be a feature in the middle to far distant background.

Since the primary visual concern revolves about the possible view of the power plants from publicly accessible view points in the park where large numbers of tourists would likely visit, a series of profiles or visual perspective were constructed to show that the view lines from these points are blocked. Perspectives are shown in Figures 2 to 7. It should be noted that no correction for trees has been incorporated into these perspectives. If the trees are included, only Plant E could be viewed from any nearby road in the park or those immediately outside the park. (Observers on the Mauna Loa strip road at a distance greater than 10 miles may be able to see one or more of the plants once they go above 6,000 feet.) For Plant E, the only areas of visibility from publicly accessible roads are from the Napau Trail parking lot and access road and the portion of Chain of Craters Road immediately to the south of Pauahi Crater and north of the Aina Loa Ranch turnoff.

It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the East Rift Zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, no visible vapors are expected from the cooling towers.

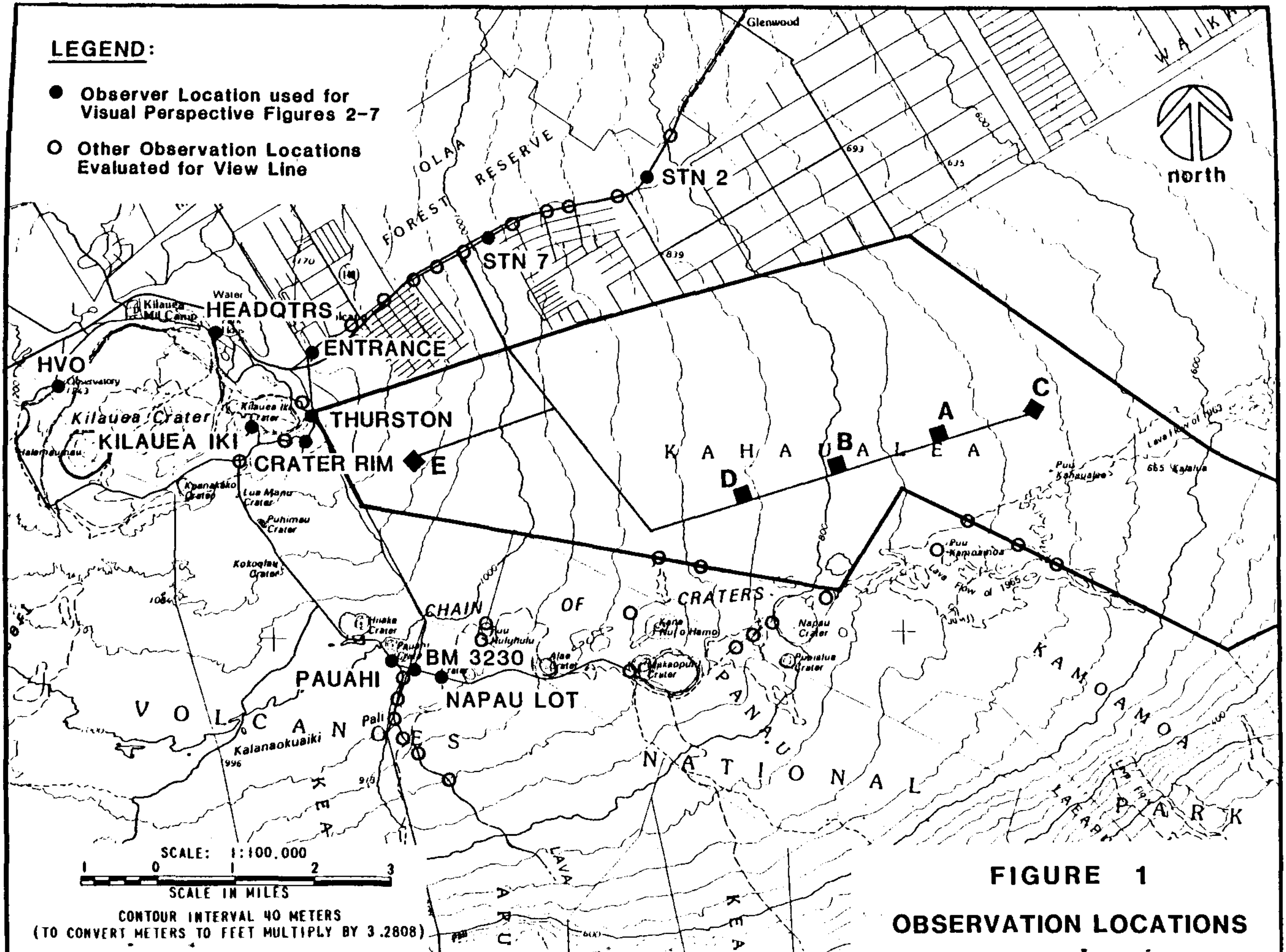

FIGURE 1

OBSERVATION LOCATIONS

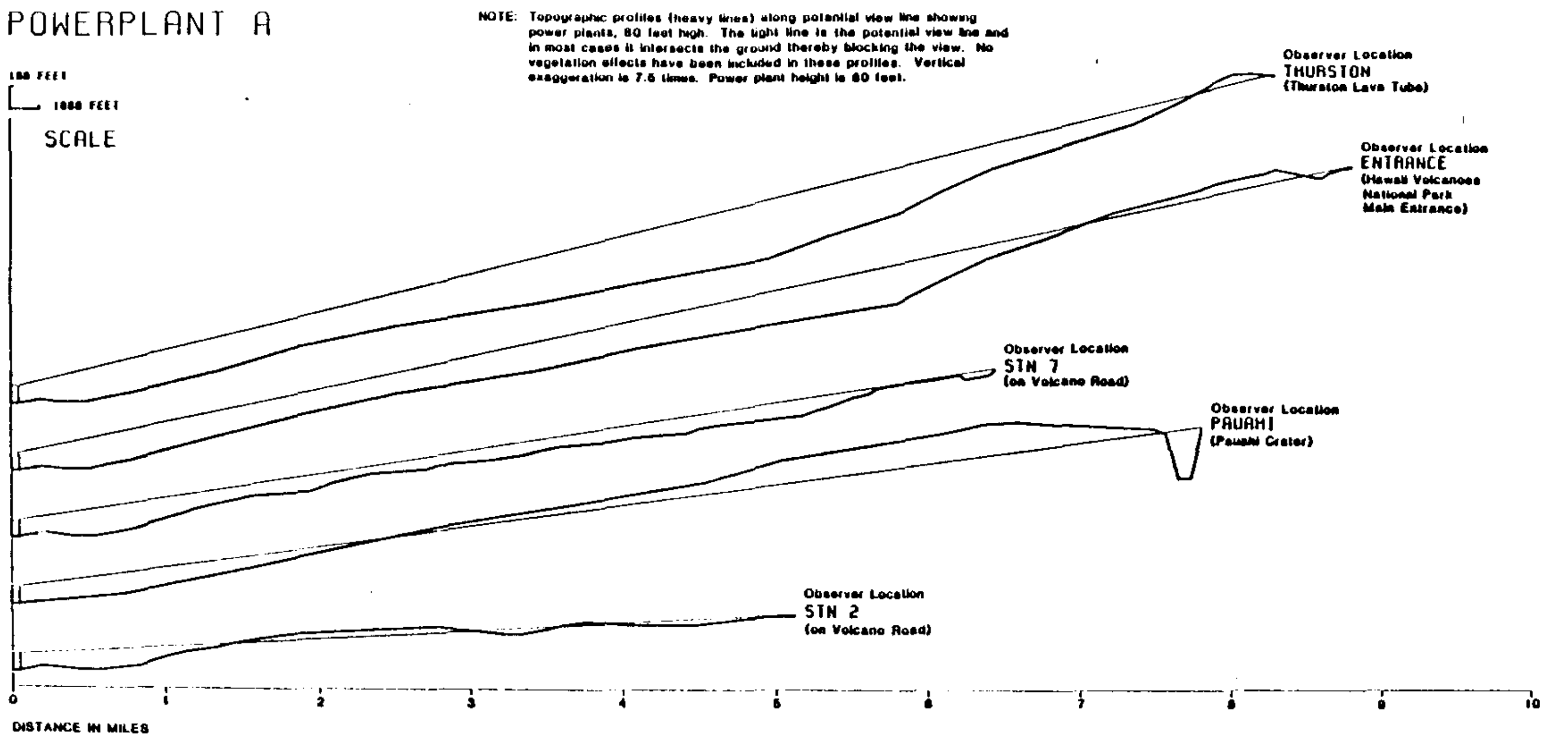

FIGURE 2

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT A

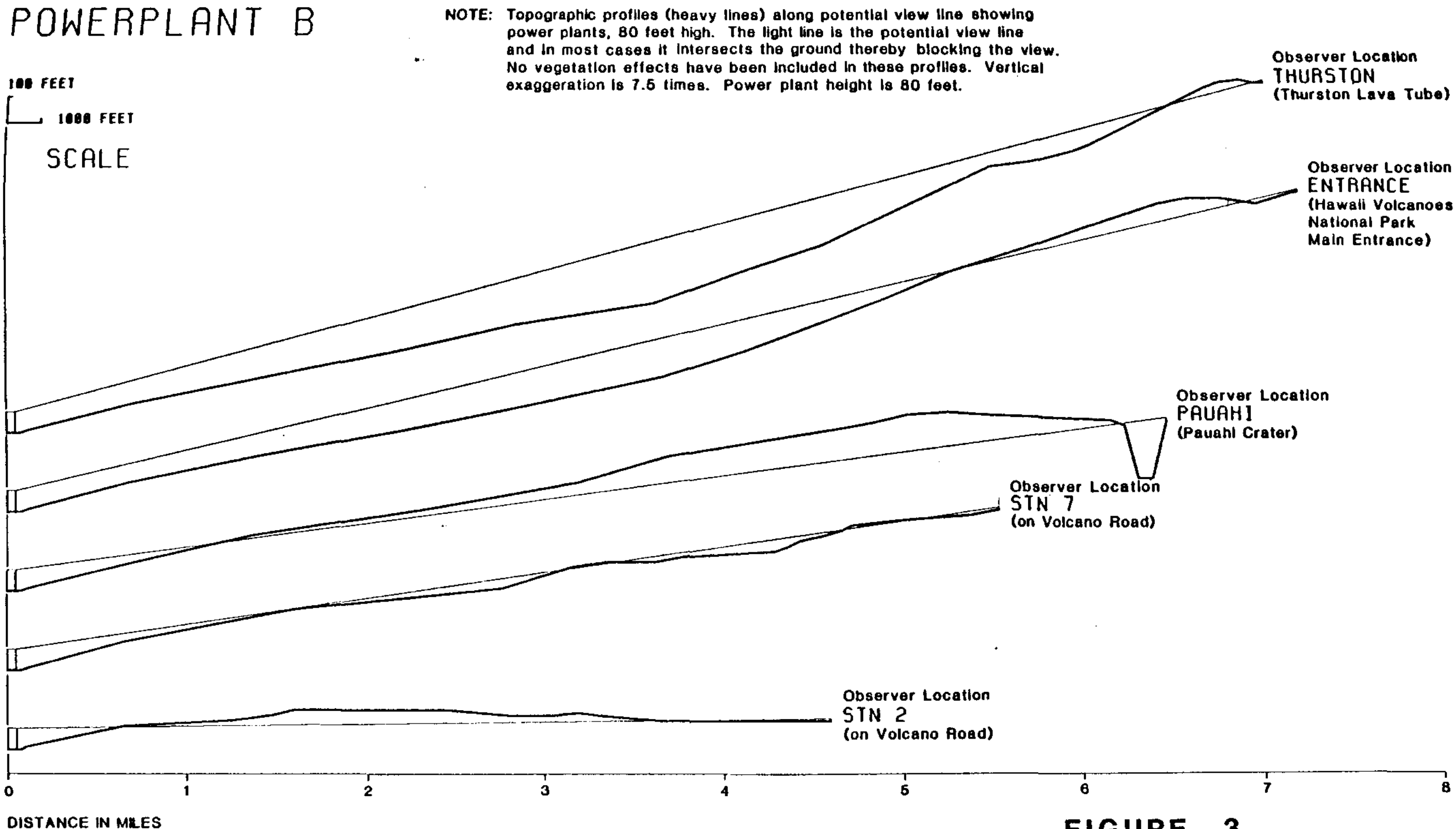

FIGURE 3

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT B

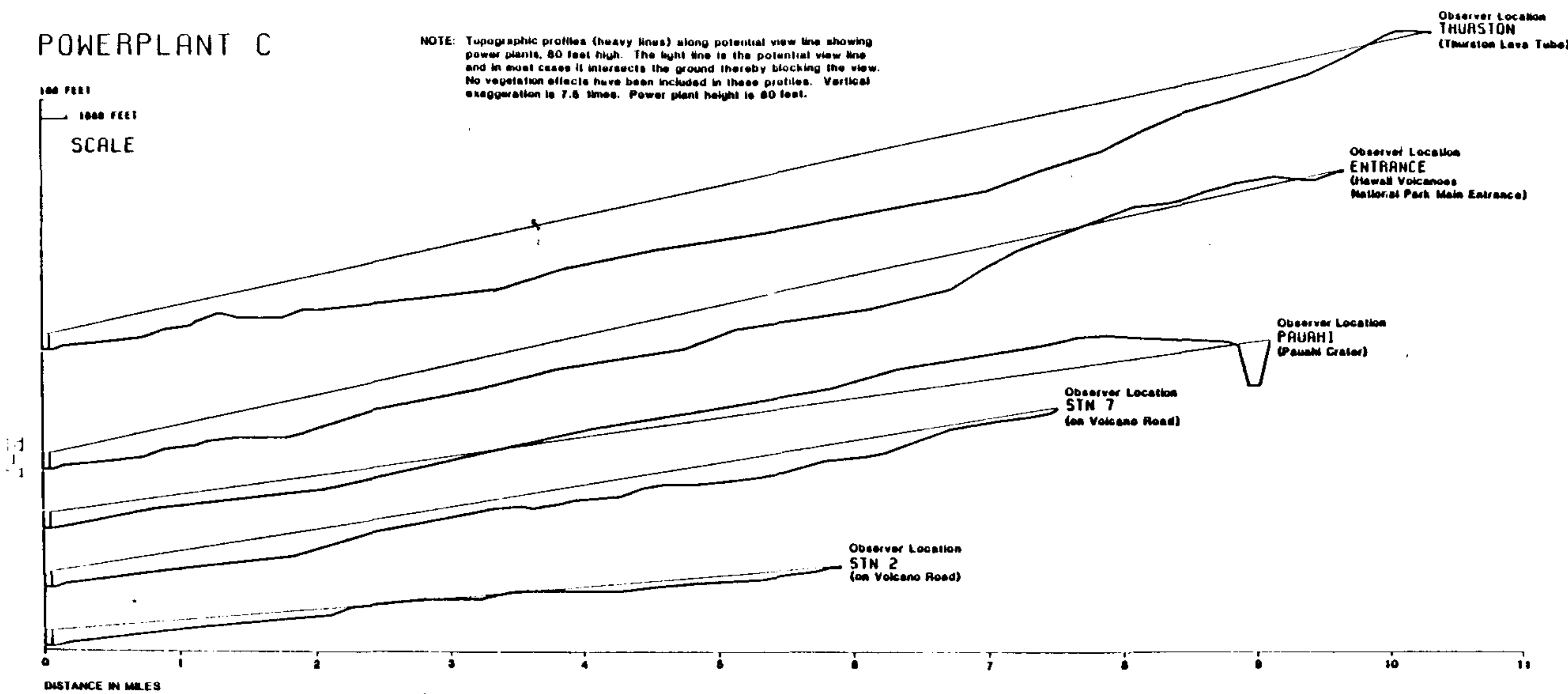

FIGURE 4

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT C

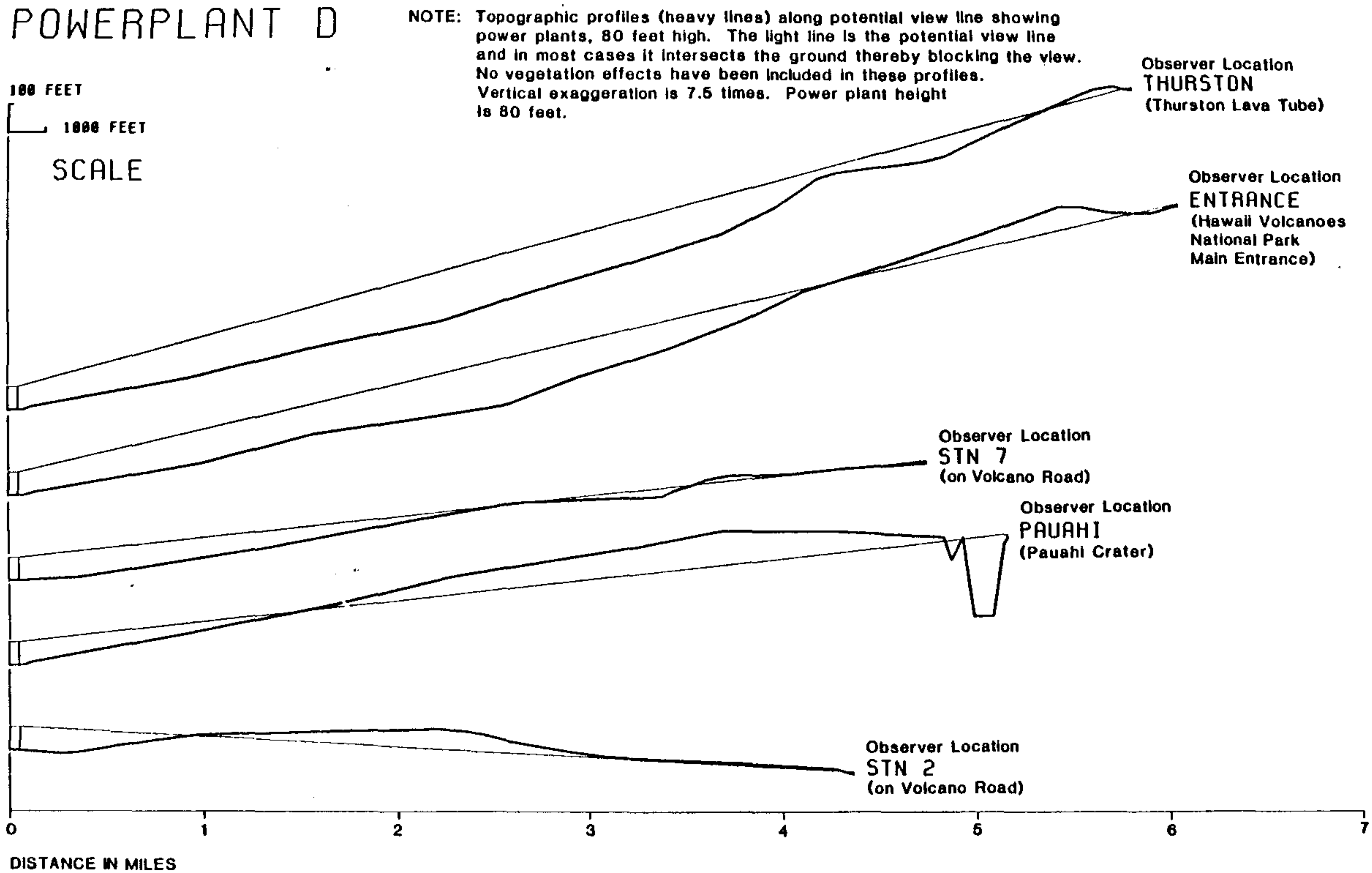

FIGURE 5

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT D

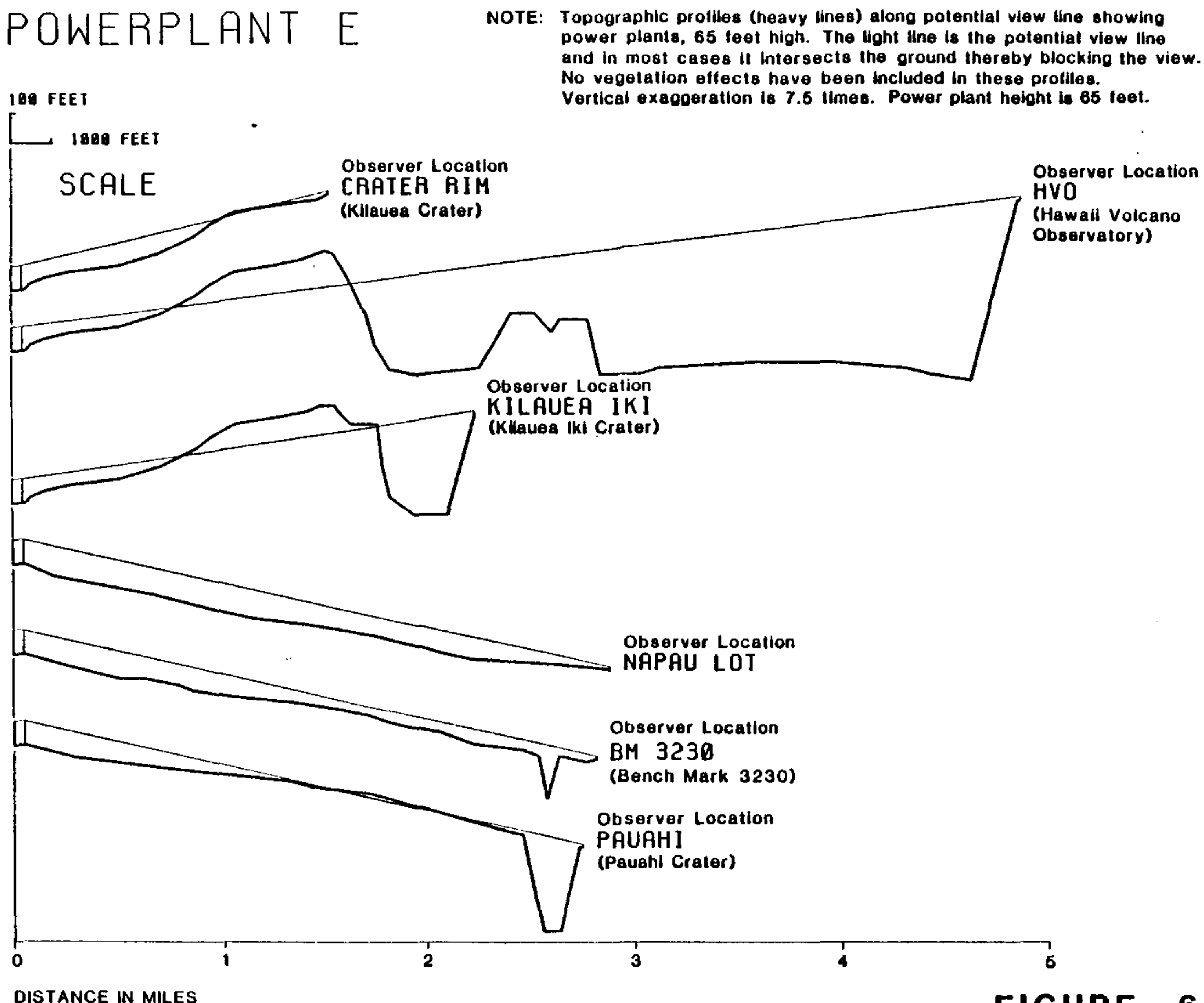

FIGURE 6

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT E

POWERPLANT E

NOTE: Topographic profiles (heavy lines) along potential view line showing power plants, 65 feet high. The light line is the potential view line and in most cases it intersects the ground thereby blocking the view. No vegetation affects have been included in these profiles. Vertical exaggeration is 7.5 times. Power plant height is 65 feet.

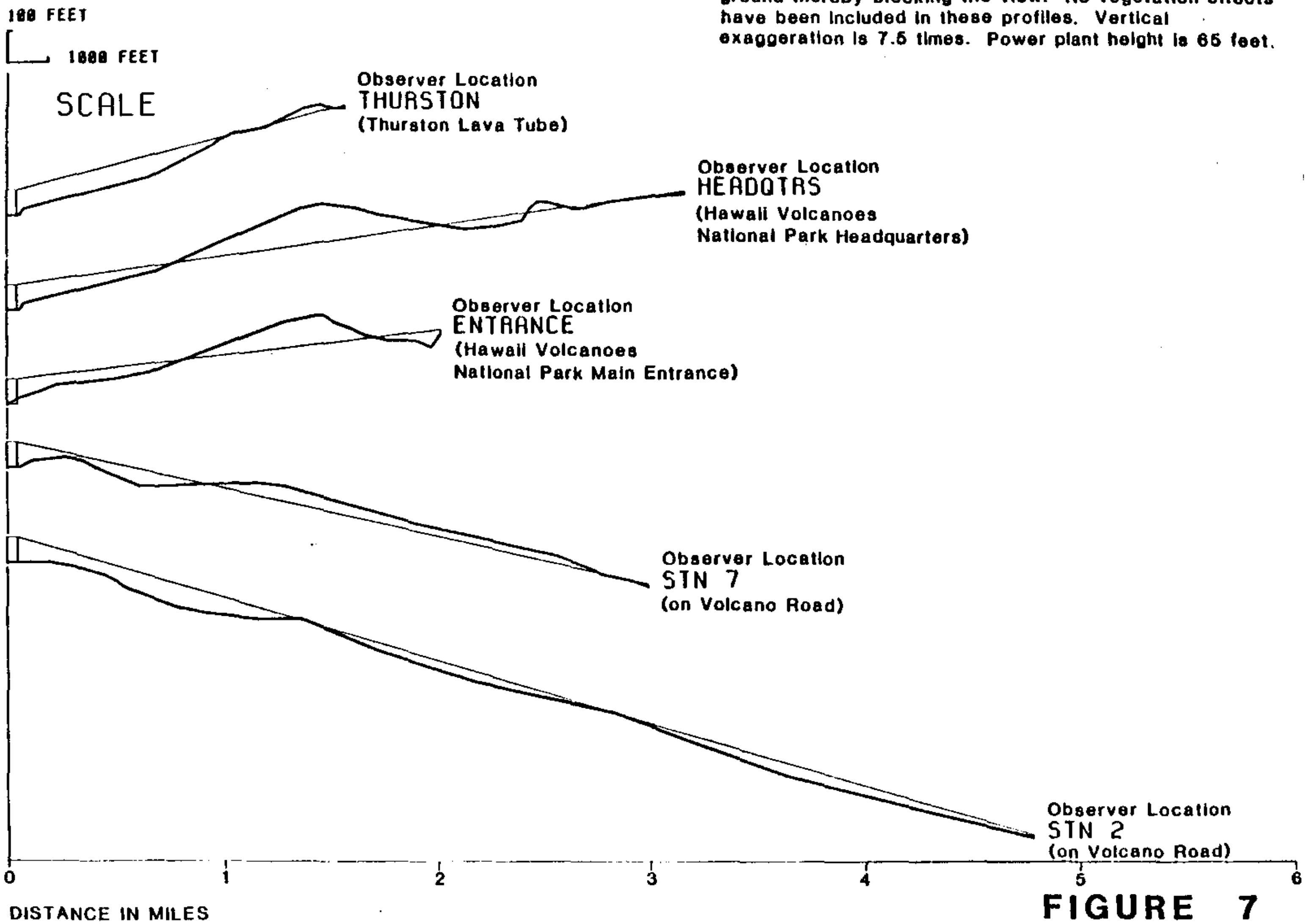

FIGURE 7

VISUAL PERSPECTIVE FROM SELECTED LOCATIONS TO POWER PLANT E

State Ex. No. 7.

ECONOMIC IMPACT ANALYSIS
OF
POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-105

State of Hawaii

DEPARTMENT OF LAND AND NATURAL RESOURCES

Division of Water and Land Development

ECONOMIC IMPACT ANALYSIS
OF
POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-105

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
September 1984

PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which addresses each of the subzone designation factors. This report analyzes the major economic considerations associated with geothermal activities within potential geothermal areas.

This report was prepared by Environmental Capital Managers, Inc. under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and Land Development, Department of Land and Natural Resources.

CONTENTS

SUMMARY

To facilitate this economic assessment, two assumptions are made: (1) a 20 to 30 megawatt(MW) plant would be constructed, and (2) the application of the geothermal wells would be for the production of electricity for local consumption only.

The overall assessment is that a 20 to 30 MW geothermal power plant will have some economic impact on a State-wide and County-wide basis, but the impact would probably not be significant. Based upon the data available, the direct wages to the 25 direct project employees will be about $560,000 per year. This direct income will stimulate a multiplier effect totalling an estimated $1.3 million. Additionally, an estimated 57 additional jobs will be created.

The selected sources of public revenue analyzed will not yield a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, only after a more complete analysis of the public revenue and public or community resource cost of a specific development will it be known whether the public revenues will outweigh the public costs.

Overall, the impact of the 25 additional households to the community will be primarily in the housing market, assuming that all the 25 workers needed by the plant come from outside the County. Realistically, only a portion will be "imported" into the County. Thus the impact on housing is not expected to be as great. Other community resources will not be affected in a significant manner.

For the production of electricity for local consumption only, the assumed 20 to 30 MW plant size being considered here is reasonable. However, direct use and other applications would alter the plant size requirements. In addition, more significant impacts on the economy would occur, both benefits and costs: more jobs, increased public revenue, increased housing and infrastructure demands, etc.

Regardless of the ultimate size of the plant decided upon, a more definitive assessment of the relative gain or loss to be realized by the existence of the geothermal plant must be made on a case-by-case basis.

ECONOMIC IMPACTS

As with any economic activity, the injection of dollars into the economy will result in direct impacts through the purchases of various goods and services from the other industries. In the case of a geothermal plant, the dollars injected into the economy may be the result of the inflow of investment capital or the dollars prevented from being "exported" from the State or the County in the substitution or displacement of approximately 390 thousand barrels of petroleum each year that would have otherwise been imported into this State for conversion into electricity.[1] The additional purchases made will, in turn, cause these industries to purchase more goods and services from other industries. The result is a chain-reaction of purchases, or a "multiplier" effect produced by the original increase in purchases.

The simpliest way to understand the basics of the multiplier effect is to consider what would happen if one were given a "brand new dollar". It is likely that the person would spend part of it and save the rest. Let's say you spent 80¢ of that dollar. For simplicity, assume that individuals and businesses were equal entities in their economic behavior. If the ratio of .8 was assumed to remain constant, then of the 80¢, 64¢ would be spent and the balance saved. If this process were to continue indefinitely until all the money was either spent or saved in this proportion, the "injection" of this "brand new dollar" would ultimately yield $5.00 in output for our simple economy.

For the purposes of this preliminary analysis, the State's 1977 input-output model will be used.[2] This model summarized the economic activities of the State at a given moment or period in time, providing information on the inter-relationships between all sectors within the economy. The analysis will concentrate on the economic impacts that may result due to the operation of the geothermal plant. It will, for now, disregard the impacts which may occur during the construction phases.

The full measure of these impacts may be offset by the degree to which monies used to finance the operations originated locally or outside of Hawaii. Additionally, County conditions may not provide the opportunities that can be found on Oahu, and as such, the full impact of the output generated may not occur. Furthermore, one of the major characteristics of the input-output model used to generate these multipliers is that it implicitly assumes that the structure of Hawaii's economy in terms of the state of technology in 1977 has not changed significantly.

OUTPUT

The revenue generated by the sale of electricity to its customers will increase the gross product of the County, as well as the State. If the assumed 25 MW plant yielded approximately 500 megawatt-hours (MWh) per day of electricity[3] at an average rate of $0.054 per kilowatt-hour (KWh)[4], the additional direct revenue would be approximately $27,000 per day or $9.9 million annually. This initial or direct output should stimulate other sectors within the local economy and within the State. These other sectors will increase their output of goods and services as a result. Based on the Department of Planning and Economic Development's multipliers for the State, a $1.00 increase in revenue can potentially increase the total output, i.e., direct-plus-indirect-plus-induced, to approximately $1.70. Therefore, the $9.9 million in direct annual revenue output could provide a long-run total annual output to the State of approximately $16.8 million.

INCOME (WAGES) TO HOUSEHOLDS

A 1982 study done for the Department of Planning and Economic Development (DPED) indicates that total wage earnings for a 25 MW plant will be approximately $560,000 per year.[5] Based on the 1977 DPED multipliers, the total impact will be approximately $1.3 million in annual incomes to households throughout the State when the full impact of the subsequent rounds of economic activity takes place.

EMPLOYMENT

According to the same 1982 study, a 25 MW geothermal plant will require approximately 25 employees to operate it. As a result of this direct employment, an estimated 57 additional jobs will be created after all the repercussions have taken place, both County-wide, as well as within the State.

EVALUATION

The assessments made thus far are rather rough approximations of what might occur. These impacts, especially the total impacts are long run in nature. That is, the subsequent indirect and induced activities do not take place instantaneously, but requires fairly lengthy periods of time for such events to take place, all other things held constant.

The overall assessment is that the assumed 25 MW geothermal power plant will have, at best, some economic impact on a State-wide and County-wide basis. Depending upon the extent to which the assumptions made regarding the inflow and outflow of dollars into the State and County economy are accurate, the total impact may vary.

PUBLIC REVENUE AND COMMUNITY RESOURCE ANALYSIS

Any economic activity results in certain gains and losses to the economy. In particular, an economic activity provides the public sector with additional sources of revenues and also increases the burden on the available public resources. In order to assess the impact of this project, an estimate of the incremental revenues and costs needs to be made. For the purposes of this preliminary analysis, only those major financial impacts likely to occur as a result of this project was considered. Order-of-magnitude estimates of the variables in this section were made where data was available and considered applicable to the assumed 25 MW geothermal plant case study. The estimation of a revenue-cost ratio was omitted at this preliminary stage of analysis.

For simplicity of analysis, it is assumed that all the employees will be brought in from outside the County. This will provide the "worst case" situation. Furthermore, it is assumed that a one-to-one relationship between employee and household exists. Thus, a total of 25 households will become the basis of the analysis. Lastly, it is assumed that all households will reside within the same district as the geothermal site.

PUBLIC SECTOR REVENUE

At the County level, three major sources of revenue can be addressed in relation to the existence of a geothermal plant. The first is property taxes, followed by fuel taxes and sewer charges.

Property Tax

Whether there will be a net gain or loss in tax revenue due to the geothermal plant will be dependent upon the net change in land values. Some of the potential factors that may influence the immediate and long-term land values are: (1) the existing land use/zoning designation, (2) the change in demand for land in contiguous areas surrounding the geothermal site, (3) the growth and density of population within the immediate community, and (4) the development of existing and new industries. Based upon the 1982 DPED study, a 20 to 30 MW plant would be situated on a 20 to 30 acre site.[6] Due to the size of the plant under consideration in this report and the assumption that it will be used for the production of local electricity consumption only, property tax revenue is expected to increase, but relatively small in magnitude. However, more detailed analysis is needed to assess the probable gain or loss to the community and to the County in terms of the property tax revenue base.

Fuel Tax

The transportation of goods and services to and from the site, as well as the commuting of employees, may increase the consumption of gasoline and diesel fuel. Any increase in fuel consumption will increase the tax base and the resulting tax revenue. It is unlikely that this will be significant, unless the level of on-site activity is high and commuting distances are extremely long.

Sewer Charge

The additional revenue is not anticipated to be significant for the combined on-site and community usage of the local sewer system, where such public system exists.

On a State-wide level, there are three major sources of public revenue that deserves treatment. The first is the general excise tax. The other is income taxes, both the corporate and the personal.

General Excise Tax

The general excise tax is the State's major source of revenue. This tax is levied at all levels of financial transactions. The revenue generated by the geothermal plant in the form of electricity sales, will be taxed at ½ of 1%.[7] Based on the estimated direct revenue of $9.9 million, the tax revenue would be about $49,000 annually. However, the interpretation of the plant's "public utility" status will ultimately determine whether this variable will be substituted for the an alternate tax source.[8]

Furthermore, general excise tax revenue will be increased by any additional personal consumption that takes place due to wages earned or higher wages earned by the plant workers. Taxed at 4% of sales, if 45% of gross wages are spent on various goods and services, this would yield an estimated average tax revenue due to personal consumption of $10,080 per year.[9]

Corporate Income Tax

The net income of the geothermal plant is subject to the corporation income tax. As such, 5.85% of the taxable base will yield additional income to the State. No data on the possible net income is currently available to estimate the income from this source.

Personal Income Tax

The wages earned are subject to Hawaii's Income Taxes. Assuming an average effective tax rate of 6%, the $560,000 in gross wages paid to the 25 employees would yield about $38,550 in income tax revenues to the State.[10]

Royalty Income

The royalty income under Section 8 of the Department of Land and Natural Resources' "Regulations on Leasing of Geothermal Resources and Drilling for Geothermal Resources in Hawaii" will provide the State with an additional source of revenue for those sites on State-owned lands or private lands with State mineral rights reservations.[11, also includes a brief discussion of potential legal issues] These royalties range from a minimum of 10 percent of the gross amount or value of the geothermal resources produced to a maximum of 20 percent. In the case of the current HGP-A plant on the Island of Hawaii, the royalty rate is set at 10 percent. Assuming this 10 percent royalty rate for our scenerio, the estimated gross annual revenue of $9.9 million would yield to the State an approximate $1 million in annual income.

COMMUNITY RESOURCE ANALYSIS

Although the on-site facility will draw upon the community's resources, this section will address only the probable impacts that may take place due to the increase in population within the immediate community or to the County. The principal resources that will be analyzed includes: housing, lower education, police and fire.

Housing

Each of the 25 households will require housing units. At current market prices, these households will probably rent or lease rather than purchase. With a tight housing market, the additional households will place increasing upward pressure on housing prices. This will be especially true in the rental market where the demand is expected to be the greatest.

Lower Education

At a Statewide average cost per pupil of $2,700 in 1982, the 25 additional households will possibly increase educational expenditures by approximately $62,100 in 1982 dollar terms.[12] This figure will cover the cost of an additional teacher that will probably be required for the estimated 23 school-age children.

Police

Assuming a ratio of 2 sworn police officers per 1,000 resident population, no additional police officers will be required for the additional 78 residents.[13]

Fire

The additional 78 residents within a community will not require additional firemen, assuming a ratio of 2.2 firemen per 1,000 population.[14]

EVALUATION

Based upon the scenerio that all 25 workers are from outside the County, the selected sources of revenues to both the County and to the State will not be a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, a more precise delineation of the type of plant, in terms of legal organization and activities, will be required to determine a more accurate public revenue estimate.

Overall, the impact of the 25 additional households to the community will be primarily in the housing market, if all 25 workers are from outside the County. The likelihood of this "worst case" assumption seems to be fairly small. Thus, it is probable that a part of the needed workforce will come from the County and therefore the housing impact will not be as great. Other community resources will not be affected in a significant manner under the current scenerio.

ASSESSMENT OF POTENTIAL RESOURCE AREAS

The following section will highlight the significant aspects of the individual geothermal sub-zones under consideration. Since housing seems to be the principal factor that is likely to have an economic impact under the existing assumptions and scenerio described above, the discussion will limit its focus on the general housing characteristics in the area. The first five zones are on the Island of Hawaii and the last two are on the Island of Maui.

KILAUEA EAST RIFT ZONE, HAWAII

For the island of Hawaii, the estimated rental vacancy rate is estimated to be 14.1% based on the 1980 Census.[15] The homeowner vacancy rate equalled 2.5%. In 1980, there was an estimated 1,883 housing units available for rent. Island-wide, then, there should be a sufficient supply of rental housing for the 25 households. However, within the Puna district, encompassing the potential Kilauea East Rift Zone,[16] only 25 housing units were counted as being available for rent in 1980. An additional 18 units were for sale. Based upon past growth rates in Puna, housing will be tight within the district.

KILAUEA SOUTHWEST RIFT ZONE, HAWAII

In the Kau district, encompassing the Kilauea Southwest Rift Zone,[17] 68 housing units were available for rent and 16 units for sale, in 1980. The housing stock within this area should satisfy the housing demand of the 25 households should a geothermal plant be located within the Kilauea Southwest Rift Zone.

MAUNA LOA NORTHEAST RIFT ZONE, HAWAII

According to the 1980 Census, the surrounding area had 40 housing units available for rent and 36 units for sale.[18]

MAUNA LOA SOUTHWEST RIFT ZONE, HAWAII

This sub-zone area lies within the same census tract area as the Kilauea Southwest Rift Zone. Thus, the comments made above also applies here.

HUALALAI NORTHWEST RIFT ZONE, HAWAII

This region had over 400 rental units vacant during the 1980 Census.[19] The potential addition of households in this area should not pose a significant problem, unless there is a major change in the market.

HALEAKALA SOUTHWEST RIFT ZONE, MAUI

For the island of Maui, the estimated rental vacancy rate is estimated to be 29.1% based on the 1980 Census.[20] The homeowner vacancy rate equalled 2.1%. In 1980, there was an estimated 1,883 housing units available for rent. Within the Makawao district,[21] 233 housing units were counted as being available for rent in 1980. An additional 37 units were for sale. If this magnitude of housing stock prevails, the impact on the local housing market is not expected to be significant.

HALEAKALA EAST RIFT ZONE, MAUI

This sub-zone area has an extremely tight housing market, as of the Census date, with no housing units for sale and only 25 rental units available for occupancy.[22]

OTHER CONSIDERATIONS

The assumption that the 20 to 30 MW plant would be used solely for the production of electricity for local consumption would be fairly accurate for the plant size being considered here. However, direct use application of geothermal power in "spa" facilities, agriculture, aquaculture, food processing, and other uses, in addition to the use of electricity to support alternate industries such as manganese nodule processing and the transmission of "excess" electricity to Oahu via an undersea transmission cable, in addition to local electricity demand, would increase the plant size requirements, or at least, increase the total production capacity of the various geothermal plants to be built.[23]

MANGANESE NODULES PROCESSING INDUSTRY

According to a 1981 study prepared by the Department of Planning and Economic Development for the United States Department of Commerce, National Oceanic and Atmospheric Administration, a manganese nodules processing plant would "...require a considerable amount of energy...ranging between 25 MW and 350 MW depending on the process used and the number of metals recovered..."[24] According to this same study, a nodule processing plant would employ between 450 to 750 people, of which 50 to 100 would be hired from outside the County. Under the Puna 3-metal oil-fired plant scenerio, it was estimated that in operation, there would be a total of approximately 900 jobs created. Additionally, the total impact on personal incomes would be an increase of about $29 million per year for the County of Hawaii and approximately $38 million for the State, as a whole. The Gross County Product would increase by $535 million, in comparison with the Statewide figure of $572 million.

SUBMARINE CABLE TRANSMISSION

The potential for fully utilizing the geothermal resources of Hawaii's Kilauea Rift Zone will materialize only if an inter-island electrical "grid" system can be established. It is estimated that the geothermal resource in this area can provide up to 500 MW of electrical energy for a century.[25] However, the electrical demand does not reside within the County, but on the Island of Oahu. Should the technical problems of such a task as laying over 160 miles of cable at depths up to 7,000 feet be overcome, a 500 MW transmission cable could "displace 6.5 million barrels of oil annually, saving as much as $195 million, at current prices.[26]

OTHER DIRECT USE APPLICATIONS

Besides using geothermal energy to produce electricity, the heat from a geothermal resource can also be applied directly. Within existing industries in the State, and most notably for islands with developable geothermal resources, direct heat can be utilized within the tourism industry for spas. Other applications include: processing agricultural products such as sugar cane, vegetable, pineapple canning, food drying for coffee, macadamia nuts, and fruits; aquaculture activities utilizing lower-temperature heat to maintain an optimal growth environment; and the heat requirements of liquor distillation. Another application of direct heat may be in the desalination of water, which may be a feasible alternative in times of "water shortages". In addition, new industries may also find geothermal energy attractive--providing for a more diverse economic base.

IMPACT OF A LARGE SCALE GEOTHERMAL PLANT

The larger scale plants will have greater impacts, along with enhanced benefits to the community-at-large as well as the economy. A plant size up to a range of 500 MW will have significant impact upon the State, County and local community economies. For such a large plant, an estimated $34.8 million would flow into the local economy over a 15-year period.[27] Upon full operation, a 500-MW plant would provide 185 direct jobs and an estimated $4.2 million in direct wages.[28]

Such a large-scale plant would draw more heavily upon the community's resources, as well as that of the State and County. The principal areas which would be most affected would be the much greater housing demands which would be placed in the local housing market. Also, the roadway system would probably require major renovations to accommodate the increased population. Additionally, the educational system, police and fire facilities, and water and wastewater facilities would need improving to meet the increased demands.[29]

Other facility requirements necessary to support a large scale geothermal development would be outside the general responsibility of State and Local Governments. The majority of such other facility requirements are private sector concerns and will be based upon "market forces". Examples of these requirements are: shopping centers, banks, garages and service stations, laundries and cleaners, etc.[30]

The ultimate size of the plant has yet to be set. However, based upon the review of the current literature and the preliminary analysis set forth in this chapter, a plant size up to about 50 MW will probably not have significant impacts on the County and State economy, as well as on the community's resources. This was also the basic conclusion of the 1982 DPED study when it stated that a plant size of up to the range of 50 MW, "...is considered to be too small..."[31] to generate any significant impacts.

Regardless of the ultimate size of the plant decided upon, a site-specific analysis will be required to provide a more definitive assessment of the relative economic gain or loss to be realized by the existence of the geothermal plant.

NOTES

1. Source: Hawaii Electric Light Company. These estimates were provided by Mr. Norman Oss, President of HELCo. For Maui, the same factors would also apply according to Maui Electric Company's Chief Engineer, Mr. Tom Sato. A 25 MW geothermal plant would produce approximately 500 MWh per day of electricity. For every 470 KWh of electricity produced by geothermal, one barrel of crude oil can be displaced. Thus, (500,000 KWh or 500 MWh)/(470 KWh)x(365 days per year) is equal to 388,298 barrels or approximately 390,000 barrels of crude oil displaced per year. The average price per barrel of oil varied between $30 for Hawaii and $33 for Maui. This is due to the difference in the mix between diesel and bunker oil. The reduction of oil imports would save Hawaii an estimated $11,648,940 to $12,813,834 each year.

2. Source: Department of Planning and Economic Development. unpublished 1977 input-output multipliers. The "electricity" sector's output, income and employment multipliers were used. County-allocated multipliers were presented in the Hawaii Integrated Assessment Study, but have not been used in this preliminary assessment.

3. see note #1.

4. DLNR. <u>Geothermal Resource Development</u>. p.22. Between the period of October 1982 to October 1983, the HGP-A plant's gross revenue per KWh generated averaged $0.054.

5. DPED, <u>Geothermal Power Development in Hawaii, Vol. II</u>, page 7-11. The 1987 figure of 25 employees and $562,500 was used. The total estimated wage earnings was rounded to $560 thousand.

6. DPED, <u>Geothermal Power Development in Hawaii, Vol. II</u>, page 6-4. "..., a surface land planning factor of 1.0 acre per MW was selected..."

7. Hawaii Revised Statutes, Sections 237-13(2)(a), 237-13.5 and 182-16. The tax revenue generated is calculated as follows: ($9,855,000 annual sales of electricity) x ($\frac{1}{2}$ of 1%) = $49,275 per year.

8. Should the geothermal plant be classified as a public utility under HRS 269, the gross earnings will be subject to the Public Service Company Tax under Chapter 239, HRS, and may also be subject to the Franchise Tax under Chapter 240, HRS.

9. The calculation is based on the assumption that 25% of the gross wage is withheld for income taxes and FICA. Of the remaining 75%, 60% of this disposable or spendable income is subsequently used for personal consumption expenditures. Thus, the product

of 75% and 60% yields 45%. If it is further assumed that the total gross wages earned will be $560,000, then $560,000x.45x.04= $10,080 per year.

10. It is assumed that the average effective tax rate is 6%. Based on two workers per household, averaging a combined adjusted gross income of $32,600 per year, with a taxable income assumed to be 80% of the adjusted gross income or $25,700, the annual tax revenue is estimated to be $25,700x.06x25=$38,550.

11. DPED's Geothermal Power Development in Hawaii, Vol. I. See the discussion in Section XI, pp. 70-73, and Section XV, pp. 93-94. This section contains a summary of the principal issues associated with mineral rights and and land ownership. According to the study, two principal questions of resource ownership must be addressed: (1) "...is a mineral reservation to be implied in some or all titles issued without expressed mineral reservations?" and (2) "...are geothermal resources included in mineral reservation clauses in grants issued prior to the 1974 amendment?". In addition, two broad issues involving surface ownership was identified: (1) type of surface deed or conveyance and (2) rights of the surface owner in the case which grants resource ownership to the State. In each case, the final determination will be made within the courts.

12. Sources include DPED's 1983 Hawaii Data Book, Tables 26 and 88, and DPED's Geothermal Power Development in Hawaii, Vol. II. The calculations makes the following assumptions: 3.11 persons per household and 29.5% under 18 years of age. The average household contains an average of .92 K-12 household member (3.11x.295). The total number of K-12 pupils equals .92 pupil per household x 25 households. Total incremental cost to lower education is equal to 23 pupils x $2,700 per pupil or $62,100.

13. 3.11 persons per household x 25 households = 78 persons. The ratio of two sworn police officers per 1,000 population was taken from DPED's Geothermal Power Development in Hawaii, Vol. II, section 7.4.1.

14. ibid.

15. DPED. 1983 Data Book. Table 539.

16. This corresponds to Census Tract 211.

17. This corresponds to Census Tract 212.

18. This corresponds to Census Tract 210.

19. This corresponds to Census Tract 215.

20. DPED. 1983 Data Book. Table 539.

21. This corresponds to Census Tract 303.

22. This corresponds to Census Tract 301.

23. DPED's Geothermal Power Development in Hawaii, Vol. I. See the discussions in Section IV, pp. 25-35, and Section IX, pp. 63-64.

24. DPED. The Feasibility and Potential Impact of Manganese Nodule Processing in the Puna and Kohala Districts of Hawaii. page xix of the Executive Summary. See also discussions in Chapter 6, especially section 6.3.1 on pp.155-159.

25. DPED. Hawaii State Plan: Technical Reference Document. page III-46.

26. DPED. Geothermal Power Development in Hawaii, Vol. I. section IX, pp. 63-65.

27. DPED. Geothermal Power Development in Hawaii, Vol. II. page 7-10.

28. ibid., page 7-12.

29. ibid., Section 7.

30. ibid., page 7-25.

31. op. cit., page 7-10.

REFERENCES

1. California Energy Commission. Cumulative Impacts Study of the Geysers KGRA: Public Service Impacts of Geothermal Development, Final Staff Report. July 1983.

2. Hawaii. Department of Land and Natural Resources. Division of Water and Land Development. Assessment of Available Information Relating to the Existence of Geothermal Resources in Hawaii. January 1984.

3. Hawaii. Department of Land and Natural Resources. Division of Water and Land Development. Geothermal Resource Development, State of Hawaii. March 1984.

4. Hawaii. Department of Land and Natural Resources. Division of Water and Land Development. Plan of Study for Designating Geothermal Resource Subzones, State of Hawaii. September 1983.

5. Hawaii. Department of Land and Natural Resources. Division of Water and Land Development. Public Participation and Information Program for Designating Geothermal Resource Subzones, State of Hawaii. March 1984.

6. Hawaii. Department of Planning and Economic Development. County Trends in Hawaii, 1970-1982. Statistical Report No. 160. July 6, 1983.

7. Hawaii. Department of Planning and Economic Development. The Feasibility and Potential Impact of Manganese Nodule Processing in the Puna and Kohala Districts of Hawaii. Prepared for the United States Department of Commerce, National Oceanic and Atmospheric Administration. November, 1981.

8. Hawaii. Department of Planning and Economic Development. State Energy Plan: Technical Reference Document. October 1982.

9. Hawaii. Department of Planning and Economic Development. Geothermal Power Development in Hawaii. Volumes I and II. June 1982.

10. Hawaii. Department of Planning and Economic Development. LongRange Population and Economic Simulations and Projections for the State of Hawaii. March 1, 1978.

11. Hawaii. Department of Planning and Economic Development. The State of Hawaii Data Book 1983: A Statistical Abstract. December 1983.

12. Hawaii. Department of Planning and Economic Development and Lawrence Berkeley Laboratory. Hawaii Integrated Energy Assessment. Volumes I-VI. June 1981.

13. Hawaii. University of Hawaii. Hawaii Natural Energy Institute and The Pacific Biomedical Research Center. Overviews of Geothermal Development in Hawaii. Volumes 1-7. June 1980.

14. SRI International. Energy Self-Sufficiency for the Big Island of Hawaii. 2 volumes. Prepared for the County of Hawaii. January 1980.

15. United States. Department of Commerce. Bureau of the Census. 1980 Census of Population and Housing: Selected Areas in Hawaii. PHC80-2-13. June 1983.

State Ex. No. 8

SOCIAL IMPACT ANALYSIS OF POTENTIAL GEOTHERMAL RESOURCE AREAS

Circular C-104

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

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PREFACE

Act 296, Session Laws of Hawaii 1983, as amended by Act 151, SLH 1984, requires that the Board of Land and Natural Resources examine various factors when designating subzone areas for the exploration, development, and production of geothermal resources. These factors include potential for production, prospects for utilization, geologic hazards, social and environmental impacts, land use compatibility, and economic benefits. The Department of Land and Natural Resources has prepared a series of reports which addresses each of the subzone designation factors. This report analyzes the major social impacts associated with geothermal activities within potential geothermal areas.

This report was prepared by Environmental Capital Managers, Inc. under the general direction of Manabu Tagomori, Chief Water Resources and Flood Control Engineer, Division of Water and land Development, Department of Land and Natural Resources.

CONTENTS

SUMMARY

This section on the social impact analysis of geothermal resource areas gives emphasis to people's perceptions, attitudes, and concerns regarding geothermal resource development and operation. Considerations are based primarily on a 20 Megawatt (MW) to 30 MW level of geothermal generation of electricity and are based on available public information.

Major social concerns considered are health aspects, noise aspects, lifestyle, culture and community setting, aesthetics, and community input. Also included is a review of the potential geothermal areas with respect to these factors of social concern. Two major community-wide survey studies mentioned below produced information relating to perceptions and concerns about the effects of geothermal development. In addition, inputs were made by community and other organizations and individuals on various occasions.

The Puna Community Survey, prepared in 1982 by SMS, Inc. for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, reported that only one-fifth of the total survey respondents felt they had been affected by the geothermal wells in Puna, on the Hawaii Island. Much about the cultural background, beliefs, practices, and lifestyles of the Hawaiian residents in Puna was reported and discussed in the survey conducted by the Puna Hui Ohana, Assessment of Geothermal Development Impact on Aboriginal Hawaiians, with indications that there is a balance of respondent's views on the economic benefits of geothermal development versus the possible social/lifestyle or environmental costs of such development. Several major studies were recently completed on existing or ambient air quality levels and proper control of geothermal emissions.

If in the course of time, development considerations expand to higher output levels than 20 MW to 30 MW electricity production and to uses other than electricity generation, comprehensive studies and analyses will need to be made on the various social and community effects which may occur within a site-specific area.

Overall indications are that the elements of major social concerns and impacts could be minimized and preservation of quality environment could be achieved by proper siting, landscaping and design of plant facilities, and careful controls and monitoring of all operations. The necessity and desirability of furthering the on-going processes of accessing community input from all sectors should be emphasized.

SOCIAL CONCERNS, GENERALLY

Health Aspects

The health aspects of geothermal resource development involve primarily the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds. The technical analyses of air/water quality are treated fully in the environmental impact analysis report, but the concerns and perceptions and attitudes of the residents regarding the health aspects of geothermal emissions are in the area of social concerns and sociological impact.

Two community-wide survey studies produced information relating to perceptions and concerns about the effects of geothermal development on elements of physical environment such as air quality. A community association in Puna, the Puna Hui Ohana, interviewed 351 Hawaiian residents in the Puna area, representing 255 families with a total population of 928 people, with results prepared in a report, Assessment of Geothermal Development Impact on Aboriginal Hawaiians (February 1, 1982). Among the questions surveyed was the following:

> Question No. 12. "What kind of change would geothermal development bring about on the physical environment (noise, air quality, visual environment) of Puna?"[1]
>
> Summary of survey results [2]:

	Response Frequencies (No. of Responses)
Very Good	10
Good	16
Slightly Good	11
Neither Good Nor Bad	46
Slightly Bad	56
Very Bad	114

A survey study conducted by SMS Research, Inc. for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, The Puna Community Survey, completed in April, 1982, interviewed 778 residents in the Puna area and among the questions asked was the following:

> Question No. 18 [3]: "Have you or members of your household been affected by those wells in any way? [Geothermal wells in Puna]."
>
> Only 18% of the respondents answered "yes" and 81% of the respondents answered "no", with 1% answering "Don't know".

Each sub-area of the Puna region showed a different proportion of "yes" and "no" responses, as follows [4]:

	"yes"	"no"	"don't know"
PUNA TOTAL	18%	81%	1%
Kapoho-Kalapana	43%	57%	0%
Pahoa	28%	72%	1%
Subdivisions (between Pahoa and Keaau)	14%	85%	1%
Keaau	4%	95%	1%
Kurtistown-Volcano	6%	93%	1%

The 18% who answered "yes" were asked, "In what ways were you affected?" [5], with mentions of negative effects of "health problems" and "smell" as follows:

Percent of Respondents Perceiving Negative Effects

	Health Problems	Smell
PUNA TOTAL	14%	71%
Kaphoho-Kalapana	38%	81%
Pahoa	8%	79%
Subdivions (between Pahoa and Keaau)	13%	58%
Keaau	0%	50%
Kurtistown-Volcano	8%	42%

(Note: percentages in these responses add to more than 100% because respondents could mention more than one type of impact)

In addition to the two major survey studies, inputs in terms of concerns, perceptions, and opinons were made by community associations and other organizations and individuals regarding the HGP-A well and the Kahauale'a Conservation District Use Application, but in the comprehensive consideration of the physical effects of geothermal development and operations on residents' health, the effects (and mitigation measures) of these activities on human health over and above the effects of natural volcanic area ambient conditions and over and above other ambient effects on health such as mold and fungi growth in the area, should be assessed. In the "Puna Speaks" case, where HGP-A shutdown was requested by Puna residents, the U.S. District Court Judge ruled that the plaintiffs did not prove their case in suit as no causation was established between the well emissions and alleged maladies.

Two major sources of information that help answer the questions and concerns are: The Revised Environmental Impact Statement for the Hawaii Geothermal Research Station Utilizing the HGP-A Well at Puna, Island of Hawaii, dated March, 1978 [6] and the Revised Environmental Impact Statement for the Kahauale'a Project dated June, 1982 [7]. These contain information and assessment of ambient air content and emission effects. In addition, two major recent sources of information that help answer the questions and concerns are: Environmental Baseline Survey, Kilauea East Rift, Puna and Ka'u Districts, County of Hawaii (Progress Report, October 7, 1983) [8], prepared for the Hawaii State Deparment of Planning and Economic Development by NEA, Inc., in which definitive additional information on ambient air composition was obtained; and Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii, January, 1984, prepared for the U.S. Environmental Protection Agency by Dames & Moore.

In its conclusions on the air quality impact of potential geothermal development in Hawaii, the Dames and Moore study reports the following, based on the Best Available Control Technology (BACT) for emission abatement:

"H_2S, particulate and trace element emission rates were all developed from data gathered at HGP-A and assuming the emission controls described above. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality. Based on these calculations, potential H_2S emissions during normal power plant operations for the development scenarios [25MW and 50MW] described in this report are well below the proposed Hawaii ambient air quality standard (HAAQS) for H_2S. However, H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emissions control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities.

"Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds."[9]

In addition to the above studies, a survey has currently been conducted by the Hawaii State Department of Health, on the health status of the Puna population exposed to low levels of hydrogen sulfide and other geothermal effluents. The study surveyed some 135 households in the Leilani Estates representing 350 people and a "control" group of 179 households in the Hawaiian Beaches Estates, representing 604 people, the control population being similar in demographic characteristics to but not having the exposure to geothermal emissions as the Leilani Estates population. A series of close to thirty questions were asked concerning health backgrounds and conditions and problems. Survey data are being processed and analyzed and as of mid-May; results are expected in about two months.

Noise Aspects

Although noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor to be controlled and monitored. In terms of people's perceptions of and concerns with the noise factor, in addition to the questions and answers reported in the foregoing section on health aspects, where the Puna Hui Ohana asked residents in Puna, "What kind of change would geothermal development bring about on the physical environment (noise, air quality, visual environment) of Puna", the SMS Puna Community Survey reported on the element of noise as a negative impact mentioned by the Puna residents surveyed.

Of the 18% who answered "yes" to the question of whether they or their household had been affectd by the wells in Puna in any way, 22% mentioned they were affected by "noise". In the Kapoho-Kalapana area the percentage mentioning noise was 38%, in Pahoa 22%, in the subdivisions between Pahoa and Keaau 16%, in Keaau 0%, and in Kurtistown-Volcano 8%. [10]

In May of 1981, the County of Hawaii Planning Department issued a set of Geothermal Noise Level Guidelines to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii. Because these guidelines answer directly to the noise concerns, they are presented in the following excerpts:

> "In granting Special Permits for the exploration and development of geothermal resources in the Puna District, the Planning Department and Commission found that there were potential adverse impacts to the surrounding area which may result from the geothermal operations. Consequently, stringent controls and conditions were attached to the respective permits. The Planning Commission assigned the Planning Director the primary responsibility for the monitoring and enforcing of these conditions.
>
> "In light of these responsibilities and the numerous noise related complaints received from residents of the Puna District concerning certain geothermal drilling operations, the Planning Department has developed the following guidelines to determine acceptable noise levels for both geothermal exploration and production.
>
> "These noise levels are intended to provide the Planning Director with the necessary guidance to review and assess geothermal operations on a case specific basis to determine whether a noise nuisance exists or not. Based on this review, should the Planning Director find that the acceptable noise levels are being exceeded and that the residents are being significantly adversely impacted by that noise, he can: (1) invoke more stringent noise mitigative

procedures and/or mitigative devices; or (2) cease further geothermal activity in accordance with the appropriate provisions of the Special Permits."

"Guidelines

In conjunction with the various acceptable noise standards and the factors specifically affecting the Puna environment, the Planning Department has developed the following noise level guidelines for geothermal activities:

"1. That the acceptable geothermal noise guidelines should be at a level which reasonably assures that the Environmental Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met."

"2. That the sound level measurements should take place at the affected residential receptors."

"3. That, in conjunction and appreciation of the other guidelines, the acceptable noise levels for geothermal development are as follows:

  a. That a general noise level of 55 dBA during daytime and 45 dBA at night not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours 7:00 p.m. and 7:00 a.m.;

  b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period;

  c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation; and

  d. That sound level measurements be conducted using standard procedures with sound level meters using 'A' weighting and 'slow' meter response unless otherwise stated.

"The guidelines for allowable geothermal noise levels are intended to provide an interim basis for assessing geothermal activities. As more information is obtained and a better understanding of both the noise levels and their impacts on the environment and the climatic conditions affecting the Puna area, these guidelines should be amended."[11]

Lifestyle, Culture, and Community Setting

The lifestyle, culture and community setting or atmosphere of an area are very much inter-related and represent a major concern in terms of the effects of any introduced changes, especially when the changes may be in the direction of industrial development in a relatively rural setting. The Puna area has the most information and the input to-date on these aspects in relation to geothermal development may for the time being be applicable to an extent to other localities. Each community, however, will have its own unique background and perceptions and goals. Each community should in the process of considering geothermal resource development contribute its own input into the assessments.

Much about the cultural background, beliefs, practices, and lifestyles of the Hawaiian residents in Puna was reported and discussed in the survey by the Puna Hui Ohana, Assessment of Geothermal Development Impact on Aboriginal Hawaiians. Among many other considerations, the study reports the following:

> "Of particular interest in assessing the cultural impact of geothermal development is the extent to which the Community members engage in traditional subsistence activities which could be in conflict with geothermal use of the land. As attachment 6-8 indicates, there is reported a high frequency of such activities with a majority of the sample fishing (66%), shoreline collecting (62%) and food gathering (59%). The practice of gathering medicinal plants (48%), gathering maile (38%) and hunting (38%) are also quite common. While these activities are common for family use, their frequency for commercial use drops substantially. Fishing (11%) is the most common of these activities practiced commercially, with shoreline collecting (7%), food gathering (5%) and gathering maile (5%) less frequent. Very little gathering of medicinal plants (2%) or hunting (1%) is engaged in commercially.
>
> "The reported frequency of a number of traditional cultural activities is presented in Attachment 6-9. The most frequent of these practicies are the sharing or exchange of food (72%), preparation of traditional Hawaiian foods (60%), singing of traditional songs (59%), and the use of traditional herbs and medicines (56%). While these activities are engaged in quite regularly by the Puna Hawaiian Community, the use of the Hawaiian language is much less common. Attachment 6-10 describes the extent to which the language

is reported to be spoken and understood. The most common response was that a few words and phrases are spoken (51%) or understood (42%). Approximately 10% of the respondents report fluency in the Hawaiian language, while 5% say they do not speak it at all...

"The final set of questions on the survey asked for respondents' views of a number of traditional Hawaiian cultural values. Attachment 6-11 presents the distributions of responses to four cultural values in terms of both their importance and the frequency with which they appear in modern Hawaiian culture. "Aloha," "love of the land," "ohana" and "respect for Kupunas" were all considered very important and common or very common among modern Puna Hawaiians. The agreement in the reponses to these four values was larger than for any other cultural characteristic assessed by the survey, and reflects a virtual consensus among the adult members of the Hawaiian Community of Lower Puna. Of particular relevance to the issue of geothermal development is the question about "love of the land," which 97% of the sample felt important or very important and 87% felt to be common or very common.

"One of the survey questions discussed in the Chapter 10 on Community attitudes toward geothermal development asked respondents how they felt about the quality of life in Puna at the present time. Attachment 6-12 presents the distribution of responses to this item. On a seven point scale from happy to unhappy the large majority responded that they were happy with the present quality of life in Puna, while only 9.5% were unhappy and 8.6% were neither happy nor unhappy." [12]

On attitudes towards the effects of geothermal development, the survey reported the following:

"One of the most stable of the findings of the survey was that the Hawaiian Community of Lower Puna is quite satisfied with the present quality of life in their Community. How, then, is the appearance of geothermal development perceived by the Community? The second major point of agreement among the respondents to the survey was that the impact of such development would be 'large' in scale. However, a consensus about the desirability of these potentially large impacts was not so readily apparent.

"A large number of impacts were perceived as negative by the respondents; and only one, economic impact, was reported to be clearly positive. Yet the question asking about the 'overall' impact of geothermal development in Puna produced responses averaging in the "neither good nor bad"

> middle ground. There seems to be a balancing of the potential economic benefits of geothermal development with the environmental and social costs of development. As indicated earlier, the actual situation is not so much one of agreement that the effects are 'neither good nor bad' as it is a polarization of people at the two ends of the continuum. Some people seem to be weighting [Sic] the economic end of the balance, while other are weighting [Sic] the environmental and social end. This situation is not unique to the Puna Hawaiian Community, and has also been described among the residents of Lake County in the Geysers geothermal field in California (Vollintine & Weres, 1976)." [13]

In the SMS study, The Puna Community Survey, respondents asked to name the best things about life in Puna today cited a great variety of factors, with 49% of the factors or items mentioned being in the category of lack of population and development, e.g. country atmosphere, rural area, uncrowded, etc., and 40% of the factors cited in the category of physical environment, and 33% of the elements cited being in the social/lifestyle factors group.

The survey also reported that the greatest divergence among attitudinal responses was between the Keaau and Kapoho-Kalapana planning areas, Keaau residents being the most concerned with economic development and jobs while Kapoho-Kalapana respondents were "suspicious of it". This was analysed in the report to be a function of the uncertainties and anxieties among Keaau residents concerning the closing down of Puna Sugar Plantation, whereas Kapoho-Kalapana's current rural character would be more affected by geothermal-related activities. [14]

Consideration of lifestyles, culture, and community setting should include the factors of the multi-ethnic background of residents in these communities, the relative lack of magnitude of impact from the beginning phase of 20 Megawatt (MW) to 30 MW geothermal plant size, and the trade-off choices, if and when development should increase in scale, between the benefits of economics in the area and attendant raising of standards of living and educational opportunities, versus the costs of lifestyle and community changes. It may be possible that with careful consideration and intelligent input and planning, a favorable composite of these elements could be achieved and retained.

Aesthetic

Although in some areas with potential geothermal resource development the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping.

The SMS study mentioned before, The Puna Community Survey, reported that of the negative impacts perceived relating to the geothermal well, 5% felt that it "looks bad". The area respondents with the greatest percentage of citing of the aesthetic aspect were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance. [15]

Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures and towers and plants with colors to blend in with the natural setting. A 20 MW to 30 MW plant complex might be given attention and care as a design model for any future expansion that may be considered desirable.

Community Input

Various channels and methods of community input are involved in the preliminary as well as future process of geothermal resource development evaluation and actualization. The community surveys by the Puna Hui Ohana and by SMS Research, Inc. for the State Department of Planning and Economic Development involved not only resident response, but also involved, in the Puna Hui Ohana survey, the work of many residents in formulating the survey, in conducting the survey, and in analysing and reporting the results.

In a study of geothermal socio-economic issues in the Hawaii Energy Resource Overviews, Volume 5, The Social and Economic Impacts of Geothermal Development in Hawaii., Dr. Penelope A. Canan, Assistant Professor of Sociology and Urban and Regional Planning at the University of Hawaii, suggested and discussed theoretical social impact assessment and management models, the use of multi-disciplinary groups, "objective" and "subjective" social indicators, the inclusion of the planning process in community process models, and the prerequisite of site specification in social impacts assessment. [16]

Public informational meetings held by the State Department of Land and Natural Resources on May 8 and 9, 1984, and on May 29 and 30, 1984 on the Islands of Hawaii and Maui, encourage public participation, so that the planning process may include, in the preliminary stage as well as later on in the process, as much input as possible from the public.

Other sources and channels of community input include the planning processes, goals, objectives and development policies formulated and adopted in community plans that become a part of the County General Plans and the State General Plan and its input processes, as well as policies brought forth by representatives of people and communities in the State Legislature.

ASSESSMENT OF POTENTIAL RESOURCE AREAS

Social Impact Factors

Depending on the geographic location of the 20 MW to 30 MW geothermal operation, social concern factors may have varying significance. Possible social factors for consideration in geothermal area assessments are shown in Table 1. Current population magnitudes and selected socio-economic characteristics of communities in or near the geothermal resource areas are referenced in Table 2A and Table 2B. Relatively significant social factors in terms of their possible effects are highlighted in the following seven potential geothermal resource areas, of which five are on the Island of Hawaii and two are on the Island of Maui.

Table 1. POSSIBLE SOCIAL FACTORS FOR CONSIDERATION IN GEOTHERMAL RESOURCE AREAS

Geothermal Resource Area	Health Noise	Lifestyle Culture Community	Aesthetic (Natural Beauty)
HAWAII ISLAND			
1. Kilauea East Rift Zone	X	XX	X
2. Kilauea Southwest Rift Zone	X	XX	X
3. Mauna Loa Northeast Rift Zone	X	X	X
4. Mauna Loa Southwest Rift Zone	X	XX	X
5. Hualalai Northwest Rift Zone	X	XX	X
MAUI ISLAND			
6. Haleakala Southwest Rift Zone	X	XX	X
7. Heleakala East Rift Zone	X	XX	X

Source/Notation: Prepared for this report on potential geothermal resource areas based on social factors considered in this section, and given the 20 MW to 30 MW geothermal electricity production level, with no site specifics or locations within overall potential geothermal areas except for the HGP-A plant and the proposed Kahauale'a project in Puna in the Kilauea East Rift Zone area. X marks where factor may be significant in its potential effects; XX marks where factor may be relatively more significant in its potential effects for consideration.

Table 2A. HAWAII ISLAND SELECTED COMMUNITIES, 1980 Census

	Puna		Kau	North Kona	
	Census Tract 210 (Upper Puna)	Census Tract 211 (Lower Puna)	Census Tract 212	Census Tract 215	Census Tract 216 (Kailua)
Resident Population	7,055	4,696	3,699	7,610	6,138
Households	2,381	1,450	1,108	2,525	2,077
Median Age of Population	30.2	27.3	29.8	29.1	28.5
Family Income (in 1979):					
Median	$18,015	$13,843	$17,555	$22,261	$20,000
Mean	$28,075	$17,632	$18,412	$26,934	$22,400

Table 2B. MAUI ISLAND SELECTED COMMUNITIES, 1980 Census

	Kula/Makena		Kihei	Hana
	Census Tract 303.01*	Census Tract 303.02**	Census Tract 307	Census Tract 301
Resident Population	3,850	1,277	6,020	1,423
Households	1,317	474	2,103	435
Median Age of Population	30.7	33.4	29.1	28.0
Family Income:				
Median	$25,850	$26,571	$22,049	$16,906
Mean	$28,161	$34,917	$24,788	$17,570

Source: 1980 U.S. Census of Population and Housing, Census Tracts, Hawaii Selected Areas. PHC 80-2-13.

* Upper Kula
** Makena

Kilauea East Rift Zone, Hawaii

In this area on the Island of Hawaii, the primary significant factor would be in terms of lifestyle, culture, and community setting as they are experienced in Puna, although given the level of geothermal operation of 20 MW to 30 MW electricity production, with an addition of some 25 workers involved directly (and brought in from the outside) as estimated in the economic assessment section, the potential effects should not be great. (The Upper Puna area had a count of 7,055 residents in 2,381 households, and the Lower Puna area had a count of 4,696 residents in 1,450 households in the 1980 U.S. Census.) As discussed in the economic assessment, the housing situation may be somewhat affected; and the small magnitude of change in lifestyle and social inter-action that may be brought about by new residents may be a small part of the lifestyle, culture and community and traffic changes already taking place in the area as a result of the influx of new residents in recent years. Although air and water quality and noise factors should be considered, they could be controlled and monitored; also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Kilauea Southwest Rift Zone, Hawaii

In this area on the Island of Hawaii, the primary significant social factor would be in terms of lifestyle, culture, and community setting as they are experienced by the people in Ka'u, although given the level of geothermal operation of 20 MW to 30 MW, the potential effects should not be great.

The Ka'u district had a count of 3,699 residents and 1,180 households in the 1980 U.S. Census. In the economic assessment the housing stock in this area is estimated to be sufficient to satisfy the housing demand resulting from a 20 MW to 30 MW geothermal plant being located within the district. The health and noise factors are important depending on where in the region a plant is located, but as discussed before, the air/water quality and the noise factor should be controlled and monitored. A portion of Ka'u is encompassed by the Hawaii

Volcanoes National Park, and the preservation of natural heritage and natural beauty is an important factor. Good aesthetics may be achieved by well planned siting, landscaping, and well designed plant architecture for geothermal activities nearby.

Mauna Loa Northeast Rift Zone, Hawaii

This zone encompasses primarily the people in the Upper Puna area, whose lifestyle and community setting may be somewhat less rural than that of the coastal Puna area, with a signficant portion of the residents having jobs in Hilo and vicinity. The air/water quality, noise factor, and aesthetics should, as mentioned before, be controlled and monitored.

Mauna Loa Southwest Rift Zone, Hawaii

This zone encompasses the southern portion of the Ka'u area, with generally similar factors for social consideration as discussed in the section the Kilauea Southwest Rift Zone.

Hualalai Northwest Rift Zone, Hawaii

In this area on the Island of Hawaii the primary significant social factor may be in terms of lifestyle, culture, and community setting as they are experienced by the people of North Kona, although this area has experienced much growth in recent years and is exposed to the presence of resort operations and the influx of visitors from metropolitan areas in many parts of the world. In 1980 Kailua, Kona had a count of 6,138 residents, with 2,077 households, and the rest of the North Kona area had a count of 7,610 residents, with 2,525 households. In the economic assessment of geothermal activities in this rift zone, the potential increase of households should not pose a significant problem barring any major change in the housing market. The elements of air/water quality, noise, and aesthetics are all important considerations for this area. The preservation of a quality environment should be achievable by careful control and monitoring of any emissions, effluents and noise, and with well planned siting, landscaping, and well designed plant complexes.

Haleakala Southwest Rift Zone, Maui

This rift zone encompasses a portion of the coastal Makena area of southwest Maui Island and a portion of the upper Kula area (Ulupalakua). The Makena area had a count of 1,277 residents with 474 households, with the of the Upper Kula area reporting 3,850 residents and 1,317 households in the 1980 U.S. Census. Recent resort development has occurred in the Kihei-Makena coastal area, introducing additional lifestyle and cultural elements into the general area. The potential effects on lifestyle, culture, and community introduced by geothermal production activities should be considered but in terms of a 20 MW to 30 MW level should not be great. The control and monitoring of air/water quality and noise elements should be achievable. The preservation of the natural scenic beauty of the area, especially Upper Kula, should be a significant consideration and may be achievable by careful site selection, landscaping and aesthetic facility designs.

Haleakala East Rift Zone, Maui

The community of Hana is in this rift zone in east Maui, with a 1980 U.S. Census count of 1,423 residents and 435 households. This community is rural/pastoral with agricultural and resort lifestyles, and the primary significant social impact may be in terms of lifestyle, culture, and community setting. Given the level of geothermal operation of a 20 MW to 30 MW plant, there may be an impact. With a potential addition of some 25 geothermal workers, there may occur a shortage of housing units in the area. Depending on where in the region a geothermal plant might be located, the control and monitoring of air and water quality and noise elements would be significant. The preservation of natural beauty in this area would be an important consideration. Some preliminary environmental baseline studies are being made for the Haleakala East Rift Zone area.

ADDITIONAL CONSIDERATIONS

It has been assumed that a geothermal plant would produce 20 MW to 30 MW of electricity. If in the course of time, development considerations expand to higher levels of output, with site-specific locations, further comprehensive and detailed studies and analyses of specific long-term and large-magnitude impacts will need to be made. Direct-use application of geothermal power such as in food processing, desalination process, and for spas and other uses may aid in diversifying the activities base of the communities and stimulating diversified agriculture and aquaculture.

In a study by the State Department of Planning and Economic Development and the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, The Feasibility and Potential Impact of Managanese Nodule Processing in the Puna and Kohala Districts of Hawaii, it was pointed out that one of the likely eventual social impacts of such industrial activity would be better schooling, with eventual improvements in social services and community facilities. The study also pointed out that efforts to mitigate the impacts of any industrial development in a rural area may not altogether prevent a minimal deterioration of the natural environment, with increased traffic and more congestion, possibly with less social cohesion. However, the study also pointed out that it is possible that less social cohesion may be desirable for facilitation of community and economic progress; also that on the other hand community social and economic progress may be enhanced and increased, with high-technology jobs serving to keep the technically educated young workers from having to leave Hawaii in search of employment, thus helping to keep families together and to increase social cohesion [17].

REFERENCE NOTES

1. Puna Hui Ohana, Assessment of Geothermal Development Impact on Aboriginal Hawaiians, p.149.

2. Ibid. p.164.

3. SMS Research, Inc. The Puna Community Survey Volume II: Detailed Results, p. 95.

4. Ibid. p. 95.

5. Ibid. p. 96.

6. Kamins, Robert M. Revised Environmental Impact Statement for the Hawaii Geothermal Research Station Utilizing the HGP-A Well at Puna, Island of Hawaii.

7. True/Mid-Pacific Geothermal Venture in Coordination with the Trustees of the Estate of James Campbell, Revised Environmental Impact Statement for the Kahauale'a Geothermal Project.

8. NEA, Inc., Environmental Baseline Survey, Kilauea East Rift, Puna and Ka'u Districts, County of Hawaii. Progress Report, October, 1983.

9. Dames & Moore, Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, p. 10-4.

10. SMS Research, Inc., Op.Cit., pp. 95-96.

11. County of Hawaii, Planning Department, Geothermal Noise Level Guidelines, pp. 1-6.

12. Puna Hui Ohana, Op.Cit., pp. 70-74

13. Ibid. pp. 136-137.

14. SMS Research, Inc., The Puna Community Survey Volume I: Overview, pp. 22-28.

15. SMS Research, Inc., Op.Cit., p. 96.

16. Canan, Penelope. The Social and Economic Impacts of Geothermal Development in Hawaii.

17. State of Hawaii, Department of Planning and Economic Development, The Feasibility and Potential Impact of Manganese Nodule Processing in the Puna and Kohala Districts of Hawaii. pp. 159-160.

REFERENCES

1. Aotani & Associates, Inc. Kihei-Makena Community Plan and Kihei-Makena Community Plan Technical Report. Prepared for the County of Maui Planning Department. 1981.

2. Burgess, John C. Potential Noise Issues with Geothermal Development in Hawaii. University of Hawaii, Hawaii Energy Institute and the Pacific Biomedical Research Center, Hawaii Energy Resource Overview, Vol. 1. Honolulu. June 1980.

3. Canan, Penelope. The Social and Economic Impacts of Geothermal Development in Hawaii. University of Hawaii, Hawaii Energy Institute and the Pacific Biomedical Research Center, Hawaii Energy Resource Overview, Vol. 5. Honolulu. June, 1980.

4. Contested Parties in Kahauale'a Geothermal Project, List of Exhibits; Exhibits 1982.

5. County of Hawaii, Planning Department, General Plan Revisions.

6. County of Hawaii, Planning Department, Geothermal Noise Level Guidelines. May 7, 1981.

7. Dames & Moore. Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii. Prepared for the U.S. Environmental Protection Agency. January, 1984.

8. EDAW, Inc. Hana Community Plan and Hana Community Plan Technical Report. Prepared for the Maui County Planning Department. October 1981.

9. The Estate of James Campbell, Written Testimony of Witnesses for the Applicant in the Application for the Conservation District Use Application for the Kahauale'a Geothermal Project. Honolulu. 1983.

10. Hawaii Revised Statutes, Chapter 205 A, The Hawaii Coastal Zone Management Law. Act 126, Session Laws of Hawaii, 1982.

11. Hawaii Revised Statutes, Chapter 226, Hawaii State Planning Act.

12. Kamins, Robert M. An Assessment of Geothermal Development in Puna, Hawaii. Honolulu. Hawaii Geothermal Project University of Hawaii. January, 1977.

13. Kamins, Robert M. and Kornreich, Donald. Legal and Public Policy Setting for Geothermal Resource Development in Hawaii. Honolulu. Hawaii Geothermal Project University of Hawaii. February, 1976.

14. Kamins, Robert M., et al. Environmental Baseline Study for Geothermal Development in Puna, Hawaii. Honolulu. Hawaii Geothermal Project University of Hawaii. September, 1976.

15. Kamins, Robert M. Revised Environmental Impact Statement for the Hawaii Geothermal Research Station Utilizing the HGP-A Well at Puna, Island of Hawaii. Honolulu. Department of Planning and Economic Development, State of Hawaii. March, 1978.

16. NEA, Inc. Environmental Baseline Survey, Kilauea East Rift, Puna and Ka'u Districts, County of Hawaii. Progress Report, April 30, 1983 through September 30, 1983. Prepared for State of Hawaii, Department of Planning and Economic Development. By Janes E. Houck. October 7, 1983.

17. Puna Hui Ohana. Assessment of Geothermal Development Impact on Aboriginal Hawaiians. Prepared for the U.S. Department of Energy February 1, 1982.

18. Siegel, B.Z. The Impact of Geothermal Development on the State of Hawaii: An Executive Summary. Hawaii Energy Resource Overview Vol. 7. University of Hawaii, Hawaii Energy Institute and the Pacific Biomedical Research Center. June, 1980.

19. Siegel, S.M., and Siegel, B.Z. The Impact of Geothermal Develop-ment in Hawaii (Including Air and Water Quality). University of Hawaii, Hawaii Energy Institue and the Pacfic Biomedical Research Center, Hawaii Energy Resource Overview, Vol. 4. Honolulu, June, 1980.

20. SMS Research, Inc. The Puna Community Survey Volume I: Overview. Department of Planning and Economic Development and Hawaii County Department of Planning. Honolulu. April, 1982.

21. SMS Research, Inc. The Puna Community Survey Volume II: Detailed Results. Department of Planning and Economic Develoment and Hawaii County, Department of Planning. Honolulu, April, 1982.

22. State of Hawaii, Department of Health and Department of Planning and Economic Development, Proposal for a Study of Hydrogen Sulfide (And Other Geothermal Effluents) in Puna, Hawaii. Progress Report, October 1, 1983 through December 31, 1983. Prepared January 7, 1984.

23. State of Hawaii, Department of Land and Natural Resources. Assessment of Available Information Relating to the Existence of Geothermal Resources in Hawaii. Honolulu. January, 1984.

24. State of Hawaii, Department of Land and Natural Resources. Geothermal Resources Development, State of Hawaii. Honolulu. March, 1984.

25. State of Hawaii, Department of Land and Natural Resources. Plan of Study for Designating Geothermal Resource Subzones, State of Hawaii. Honolulu. September, 1983.

26. State of Hawaii, Department of Land and Natural Resources. Public Participation and Information Program for Designating Geothermal Resources Subzones, State of Hawaii. Honolulu. March, 1984.

27. State of Hawaii, Department of Planning and Economic Development. The Feasibility and Potential Impact of Maganese Nodule Processing in Hawaii. Honolulu. February, 1978.

28. State of Hawaii, Department of Planning and Economic Development. The Feasibility and Potential Impact of Manganese Nodule Processing in the Puna and Kohala Districts of Hawaii. Department of Planning and Economic Development and U.S. Office of Ocean Minerals and Energy. Honolulu. November, 1981.

29. State of Hawaii, Department of Planning and Economic Development, and the Lawrence Berkeley Laboratory, University of California. Hawaii Integrated Energy Assessment, Executive Summary. January, 1981.

30. State of Hawaii, Department of Planning and Economic Development, and the Lawrence Berkeley Laboratory, Unviersity of California. Hawaii Integrated Energy Assessment, Vol. VI. Perceptions, Barriers and Strategies Pertaining to Development of Alternate Energy Sources in the State of Hawaii. 1980.

31. State of Hawaii, Department of Planning and Economic Development. The Hawaii Coastal Zone Management Law. (An Assessment in Response to Act 126, Session Laws of Hawaii 1982). January, 1984.

32. True/Mid-Pacific Geothermal Venture in Coordination with the Trustees of the Estate of James Campbell, Master Plan for Exploration & Development of Geothermal Resources. Submitted to: State of Hawaii, Department of Land and Natural Resources. February, 1982.

33. True/Mid-Pacific Geothermal Venture in Coordination with the Trustees of the Estate of James Campbell, Revised Environmental Impact Statement for the Kahaaule'a Geothermal Project. Prepared by R. M. Towill Corporation. Honolulu. June, 1982.

34. U.S. Bureau of the Census. 1980 Census Population and Housing Census Tracts, Hawaii, Selected Areas. PHC 80-2-13. June, 1983.

State Exhibit No. 14

A REPORT ON GEOTHERMAL RESOURCE SUBZONES FOR DESIGNATION BY THE BOARD OF LAND AND NATURAL RESOURCES

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

A REPORT ON GEOTHERMAL RESOURCE SUBZONES FOR DESIGNATION BY THE BOARD OF LAND AND NATURAL RESOURCES

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
August 1984

GEORGE R. ARIYOSHI
Governor

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PREFACE

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii under authority of Act 296, SLH 1983, signed into law on June 14, 1983 by Governor George R. Ariyoshi. Once subzones are established, all geothermal activities including the exploration, development, and production of electrical energy may be conducted only in the designated geothermal resource subzones.

The objective of this report is to provide information to the Board of Land and Natural Resources so that it may designate geothermal resource subzones in the State of Hawaii as prescribed in Act 296. To the extent provided by Act 296, SLH 1983, all existing statutes, ordinances, and rules are to be respected and are not superseded by this effort.

The State of Hawaii was assessed for geothermal resource potential and an estimate was made for each island and presented on a county-by-county basis as provided by Act 296, SLH 1983. The various studies were prepared using currently available public information. The existing information was examined and incorporated into technical reports, where applicable and relevant. This report represents a compilation of the various technical reports.

Department of Land and Natural Resources

ACKNOWLEDGEMENTS

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Hilo Electric and Light Company
Maui Electric Company, Ltd.
Barnwell Geothermal Corporation
Puna Geothermal Venture
True Geothermal Energy Company
Mid-Pacific Geothermal, Inc.
Geothermal Resource Technical Committee
Department of Health
Department of Planning & Economic Development
Hawaii Institute of Geophysics
Environmental Center, University of Hawaii
Hawaiian Volcano Observatory, USGS
U.S. Department of Energy
Planning Office, DLNR
Division of Land Management, DLNR
Division of State Parks, DLNR
Division of Forestry and Wildlife, DLNR
Division of Water and Land Development, DLNR

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EXECUTIVE SUMMARY

Background

Act 296, SLH 1983, designated the Board of Land and Natural Resources with the responsibility for designating geothermal resource subzones in the State of Hawaii. The Chairperson assigned the subzone task to the Division of Water and Land Development and designated the office of the Deputy to the Chairperson to coordinate Departmental activities. The Division of Land Management was designated to provide assistance in the area of leasing of state geothermal resources and the Department's Planning Office was designated to assist in matters dealing with conservation land use districts. Other Divisions were asked to provide staff assistance as appropriate.

The Division of Water and Land Development began work soon after Governor Ariyoshi signed Act 296, SLH 1983, into law on June 14, 1983. A Plan of Study was completed outlining the designation strategy. The principle elements of this strategy included a literature review of available information, assessment of geothermal resources in the State, the identification of potential geothermal resource areas for electrical power generation, examination of impact analysis of social, economic, environmental, geologic hazard factors, and compatibility with land uses. Included in the designation process was a public information and participation effort by the Department's staff to obtain community concerns. Several public information meetings were held in the areas most likely to be affected by geothermal resource developments. A departmental target for completing the initial designation of geothermal resource subzones was set at December 1984.

The Legislature in mandating the subzone effort by the Department of Land and Natural Resources did not provide any financial and manpower resources. The shortcomings, however, was relieved by the State Department of Planning and Economic Development who provided funds to the Department for temporary hires and for necessary supporting services for the project. The Department sought and obtained the assistance of organizations including federal, state, and county agencies. The acknowledgments listed in other parts of this report list the many organizations and agencies who participated in this effort.

During the assessment process, the 1984 State Legislature enacted Act 151, SLH 1984, amending Act 296, SLH 1983. A significant amendment related to the grandfathering of two sites in Puna, Hawaii where existing exploration for geothermal resources has been underway since early 1981.

Conclusions

The assessment of Hawaii's geothermal resources involved the analysis of available scientific information. To initiate this activity the Department enlisted the help of a technical committee comprised of scientists in fields of geophysics, geochemistry, geology, engineering and hydrology. This committee conducted a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. Twenty separate areas were identified and studied. Of these, seven areas were identified and mapped as having high temperature geothermal resources of 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9840 feet. Five areas are located on the island of Hawaii and two on Maui. Five other areas in the State were identified as having low temperature geothermal resources of less than 125 degree celsius. These areas are located on the islands of Hawaii, Maui and Oahu.

Examination of the seven areas relative to social, economic, environmental, geologic hazards, and compatibility with land uses reveal several impacts that may result from the exploration, development and production of geothermal resources for electrical power generation. Weighting of the assessment criteria was based upon an acceptable balance between the factors set forth in Act 296, SLH 1983.

Considered also in the evaluation of impacts was the provisions of Chapter 226, the Hawaii State Planning Act. The statutory objective, "increased energy self-sufficiency" and statutory policies "accelerate research development and use of new energy sources" and "promote the use of new energy sources" were considered. Additionally, the State Energy Plan developed as one of the Hawaii State Planning Act's twelve Functional Plans specifies the need to develop alternate energy resources, including direct solar energy; indirect solar energy such as wind, hydropower potentials, biomass, and ocean thermal differences; and geothermal energy.

After evaluating the seven potential geothermal resource areas on the basis of resource availability, prospects for utilization and examining the social, environmental, economic, geologic hazards, compatibility with land use, in addition to the statutory State energy objectives and policies, the following sites were determined as deserving consideration for designation as geothermal resource subzones by the Board of Land and Natural Resources:

Kilauea Lower East Rift, Hawaii
Kilauea Upper East Rift, Hawaii
Haleakala Southwest Rift, Maui

The above areas have the following common desirable elements for the exploration, development, and production of geothermal resource energy:

* potential for developing geothermal resources.
* interest in exploration, development and production of geothermal resource energy.
* commitment towards geothermal resource energy as a viable alternate energy source for Hawaii.
* advanced technology in geothermal resource development, such as emission control systems, noise control systems, well and power plant designs, and safety provisions from lava flows, reduces the concerns for public health and safety.
* potential degradation to the environment has been fully investigated and mitigation measures considered.

Recommendation

That the Board of Land and Natural Resources designate the Kilauea Lower East Rift, Island of Hawaii, Kilauea Upper East Rift, Island of Hawaii, and the Haleakala Southwest Rift, Island of Maui as geothermal resource subzones.

A description of the areas follows:

Kilauea Lower East Rift, Island of Hawaii

The area shown in Figures 1 and 2 identifies two separate sites--the Kapoho section and the Kamaili section. The probability of locating high temperature geothermal resources is estimated to be greater than 90 percent and the prospect for development and production of electrical energy is good. Relatively recent volcanic flows in the 1950's and 1960's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of geothermal resources.

The Kapoho Section, approximately 5939 acres lies adjacent to two subzones established by the Legislature in Act 151, SLH 1984. The extreme eastern end of the proposed Kapoho section is zoned as conservation due to relatively recent lava flows with the rest of the area zoned as agriculture. The northern boundary is buffered by a 2000-foot area where sensitive forest areas are located. The western end abuts Leilani Estates, a sparsely populated subdivision. The southern boundary generally follows the 90 percent resource probability line.

The area includes 279 acres of an existing Geothermal Resource Mining Lease R-4 issued to Puna Geothermal Venture.

The existing subzones are identified by Geothermal Resource Mining Lease R-2 issued by the Department of Land and Natural Resources for approximately 816 acres to Kapoho Land Partnership, subleased to Puna Geothermal Venture (Thermal Power Company, Dillingham, Inc. and Amfac) and Geothermal Resource Mining Lease R-3 issued to Barnwell Geothermal Corporation by the Department of Land and Natural Resources for approximately 769 acres. The two subzones are zoned agriculture by the State Land Use Commission.

The Kamaili Section comprised of 5519 acres, is entirely located in agricultural zoned lands. A Natural Area Reserve System (NARS) is located west of the area and Leilani Estates lie to the east. The 90 percent probability line is to the south. A 2000-foot buffer area has been provided to separate the NARS area from the proposed Kamaili Section. Also, the conservation district lands lying to the southeast having high quality native forest serve to buffer a portion of the proposed Kamaili area from Leilani Estates.

Kilauea Upper East Rift, Island of Hawaii

This area of approximately 5300 acres shown in Figure 3 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to habitat the area and high quality native forest are located north of the rift zone. Other impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, intermittent volcanic activity centered at Puu O has been taking place in the proposed subzone area. The location of geothermal wells and power plants should be carefully sited on older or recently cooled lava flows. When the current eruption activity has ceased, drilling and construction can take place at the risk of the developers.

The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2000-foot buffer zone to both the Volcanoes National Park and the Wao Kele O Puna Natural Area Reserve. The proposed subzone area includes only a small portion of the natural forest and encroachment has been minimized to concentrate development activities towards the rift or volcanic flow areas. By limiting the range of the northern boundary, 75% of the potential resource area remains protected and maintained as high-quality native forest.

Other potential impacts may be mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

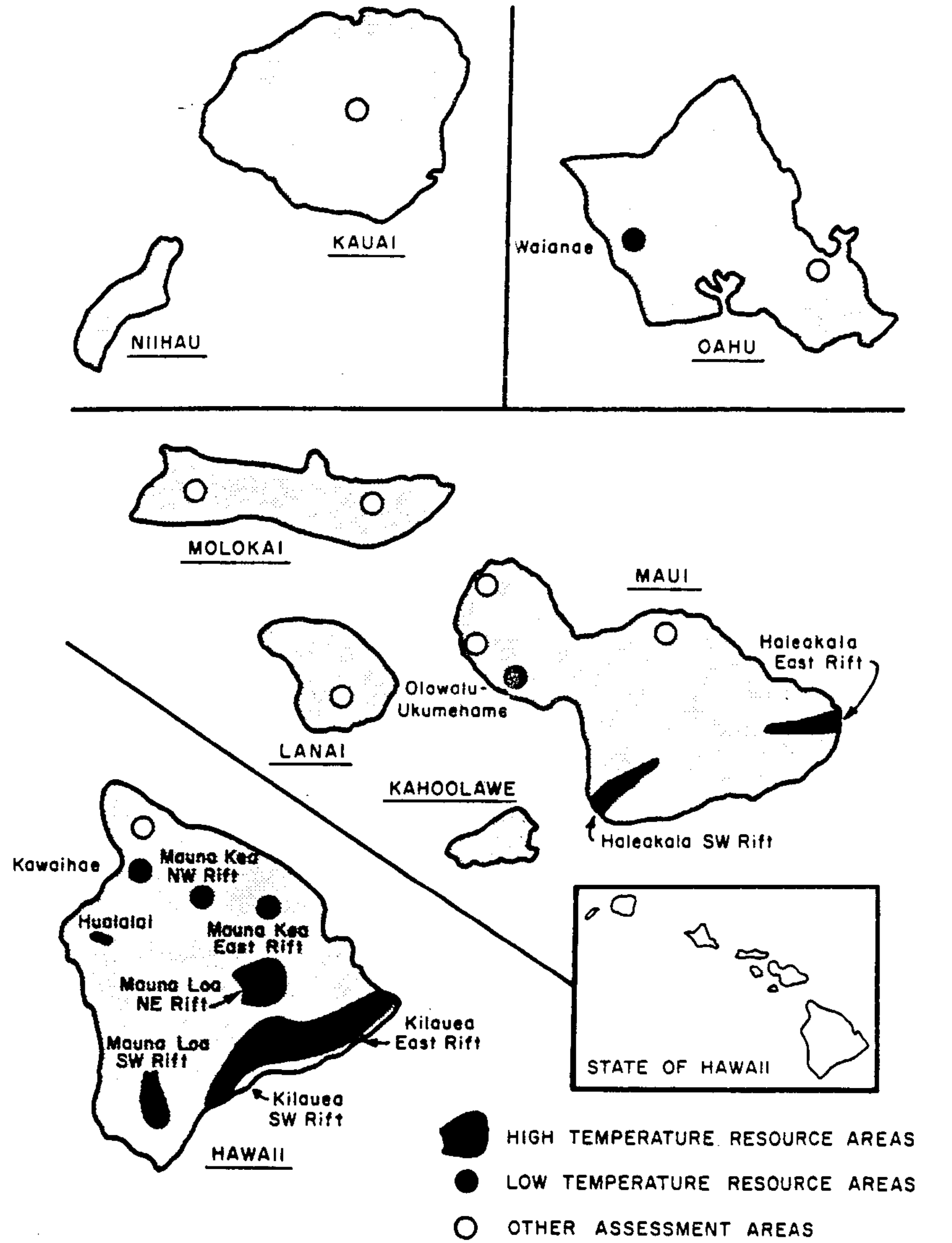
The area covering 4154 acres shown in Figure 4 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

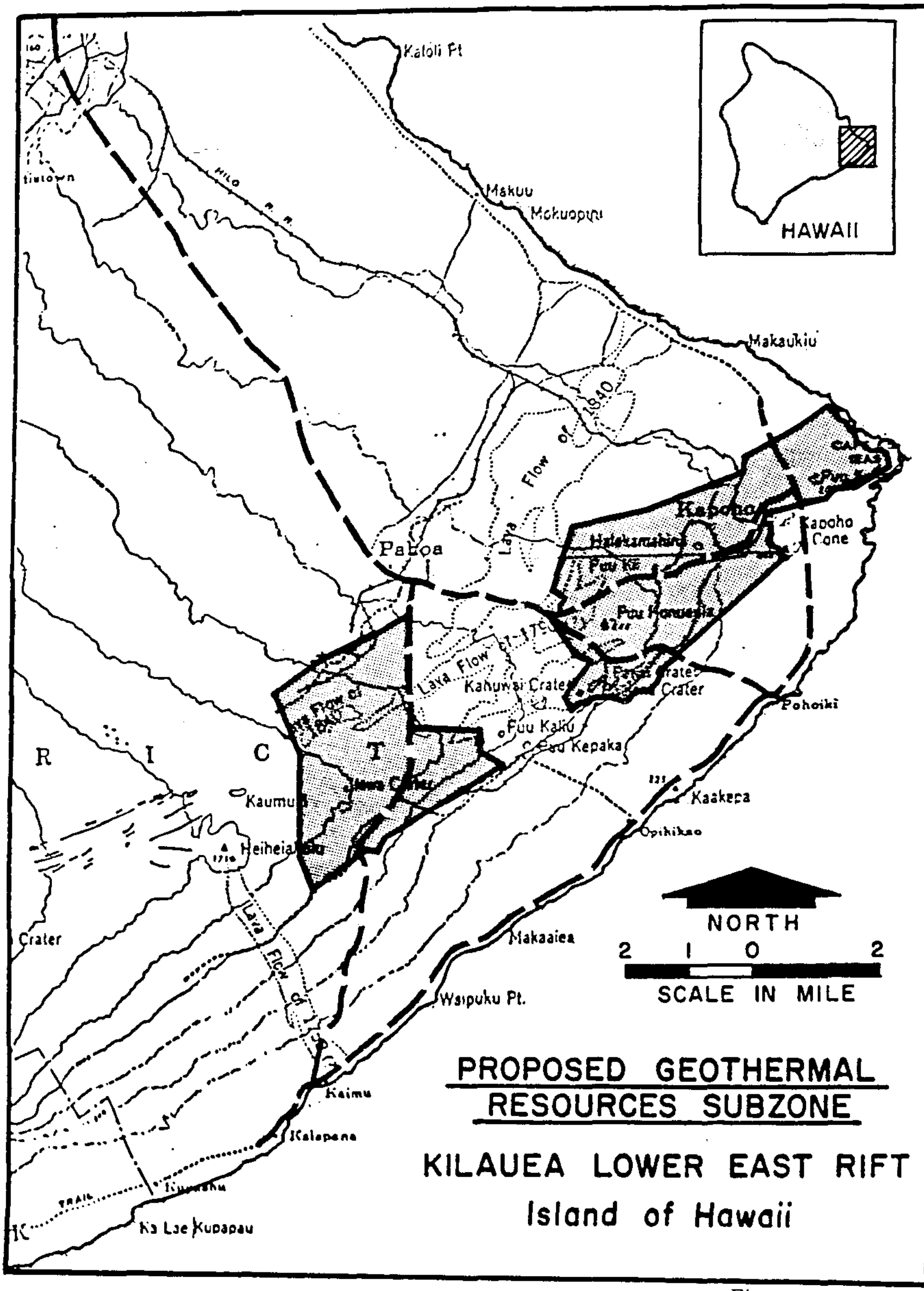
Impacts expected are to scenic and aesthetic values; including noise, lifestyle, culture and community setting, air quality, employment and housing needs.

These impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.

Figure 1.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES





HAWAII
Kaloli Pt
Makuu
Mokuoqini
Makaukiu
Lava Flow of 1840
Kapoho Cone
Pahoa
Lava Flow
Kahuwai Crater
Puu Kaliu
Pohoiki
Kaakepa
Opihikao
R I C T
Kaumu
Heiheia
Crater
Makaaiea
Waipuku Pt.
Kaimu
Kalapana
Ka Lae Kupapau
NORTH
2 1 0 2
SCALE IN MILE
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
KILAUEA LOWER EAST RIFT
Island of Hawaii

Figure 2.

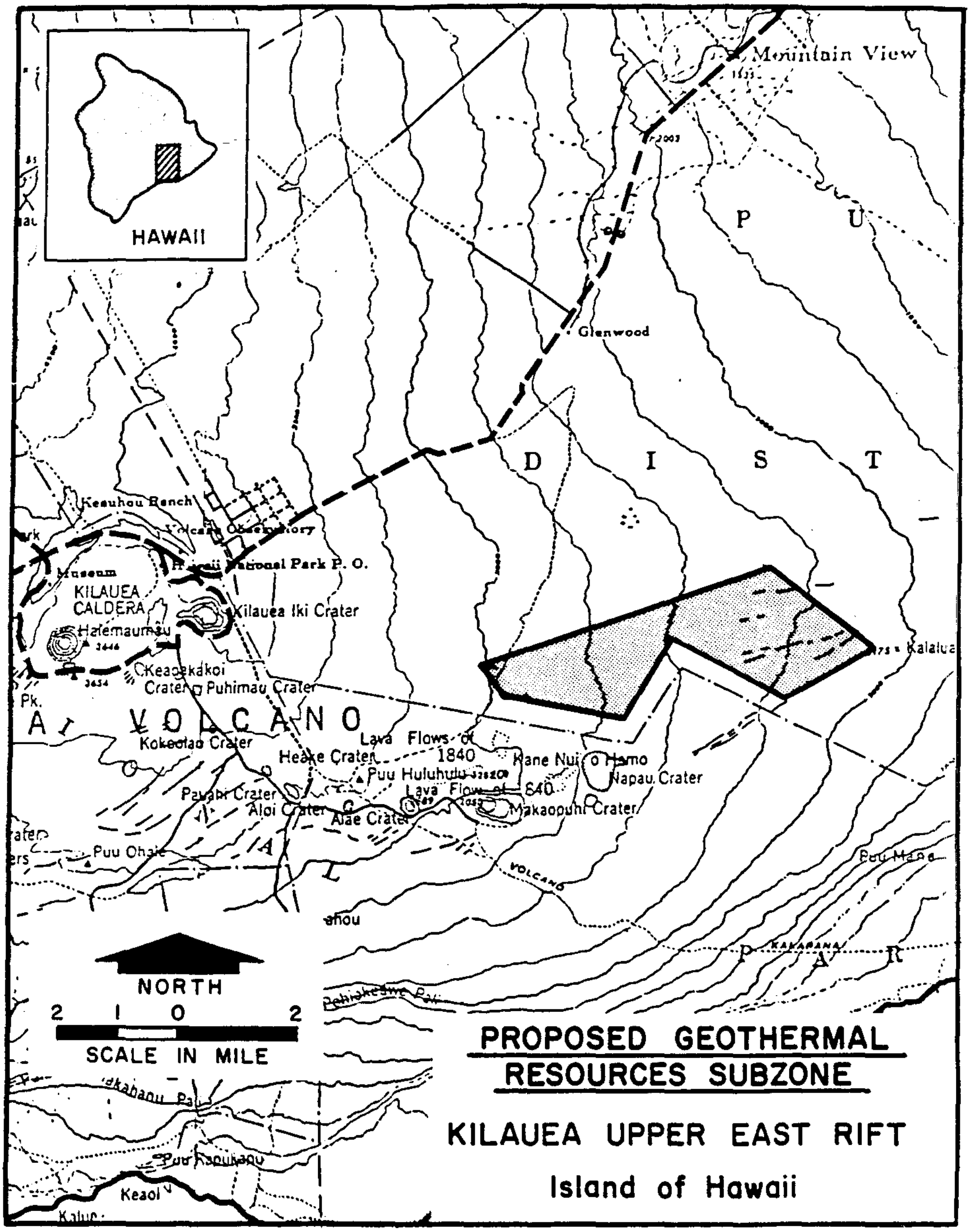
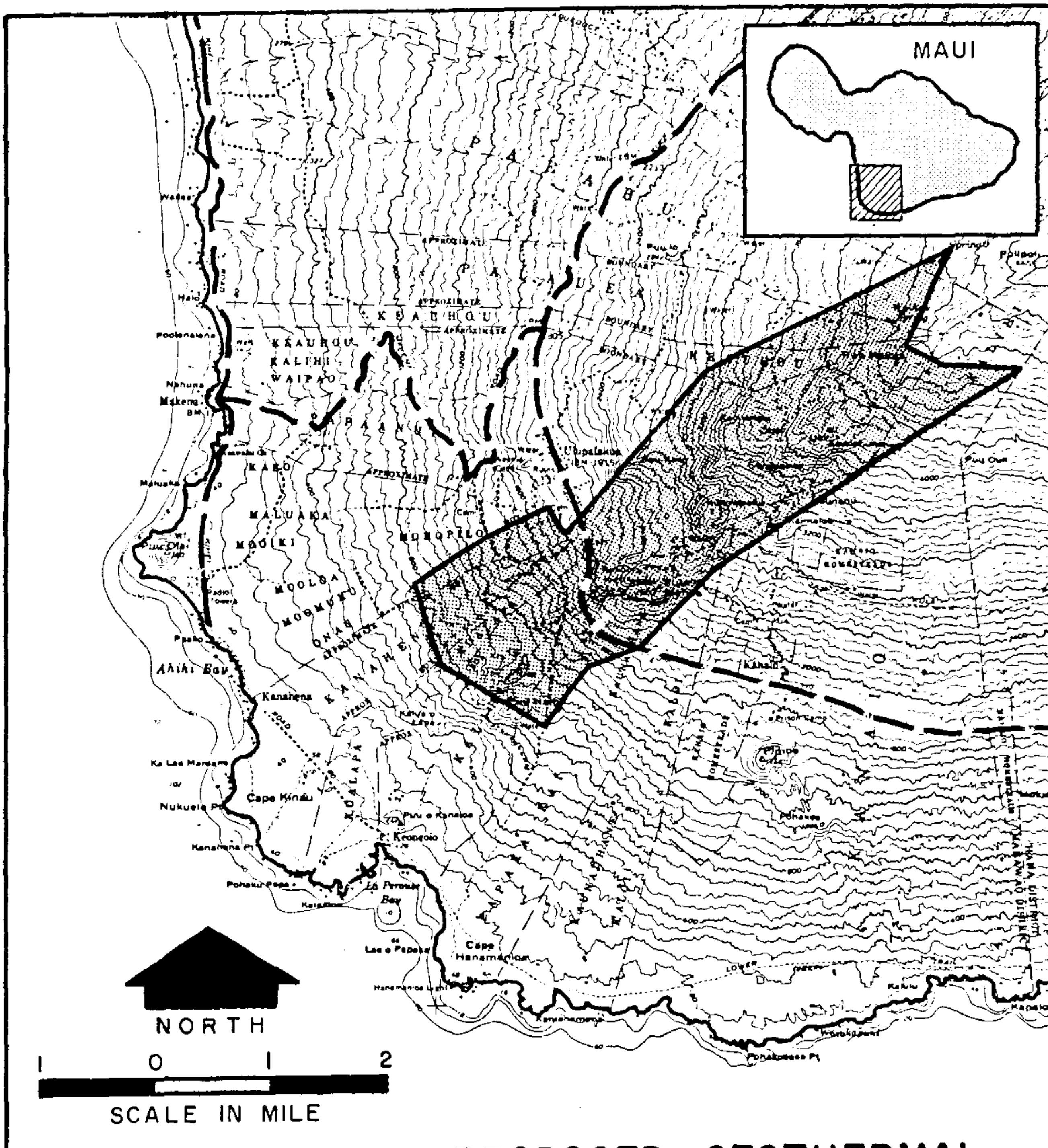

PROPOSED GEOTHERMAL RESOURCES SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii
HAWAII
NORTH
2 1 0 2
SCALE IN MILE
Mountain View
Glenwood
P U
D I S T
Keauhou Ranch
Volcano Observatory
Hawaii National Park P. O.
Museum
KILAUEA CALDERA
Kilauea Iki Crater
Halemaumau
Keanakakoi Crater
Puhimau Crater
VOLCANO
Kokoolau Crater
Lava Flows of 1840
Heake Crater
Puu Huluhulu
Kane Nui o Hamo
Napau Crater
Pauahi Crater
Aloi Crater
Alae Crater
Makaopuhi Crater
Puu Ohale
Kalalua
Puu Mana
Puu Kapukapu
Keaoi

Figure 3.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

HALEAKALA SOUTHWEST RIFT

Island of Maui

Figure 4.

INTRODUCTION

Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 by Governor George R. Ariyoshi. The legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State. Once the subzones are established, all geothermal development activities may be conducted only in these designated subzones. Pursuant to the provisions of HRS Chapter 205-5.2(a)-(c), this report was prepared to assess currently available information relating to the existence and the impacts of geothermal resources in Hawaii.

This report presents a county-by-county assessment of potential geothermal resource areas. The report is divided into the following sections: legal authority, statewide assessment of geothermal resources, geothermal technology, assessment factors, community concerns, evaluation of impacts on potential geothermal resource areas, conclusions on potential geothermal resource areas, and recommended subzones.

LEGAL AUTHORITY

Introduction

Act 296, SLH 1983, relating to geothermal energy, is the basis for this effort. This Act charges that the Board of Land and Natural Resources designate geothermal subzones. Section 3 of this Act requires the Board to "adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91." This mandate is provided for under Title 13, Chapter 184, "Designation and Regulation of Geothermal Resource Subzones" of the Department of Land and Natural Resources' Rules and Regulations. Finally, Act 151, SLH 1984, clarified various aspects of existing geothermal development activities within the State and the roles of State and County governments.

Act 296, Session Laws of Hawaii 1983

Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 by Governor George R. Ariyoshi.

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii. Once subzones are established, all geothermal activities including the exploration, development, and production of electrical energy may be conducted only in the designated geothermal resource subzones.

Some of the highlights of Act 296, SLH 1983 include:

* Provides for the designation of Geothermal Resource Subzones in each of the four State land use districts--conservation, agriculture, urban, and rural.

* The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones.

* The Board of Land and Natural Resources shall adopt administrative rules to designate geothermal resource subzones.

* The administration of the use of subzones for exploration, development, production and/or distribution of electrical energy shall be governed as follows:

    * BLNR for conservation districts.

    * Existing State and County laws for agriculture, urban, and rural districts.

* No Land Use Commission approval is necessary for the use of subzones.

* Provides for contested case hearing. Upon request, the hearing shall be conducted by the BLNR or County agency prior to the issuance of a geothermal resource permit.

* Any property owner may petition the BLNR to have an area designated as a geothermal resource subzone.

* An EIS is not required for the assessment of areas.

* The BLNR beginning in 1983 shall conduct a county-by-county assessment of potential geothermal resource development areas. The assessment shall be revised or updated at the discretion of the BLNR once every 5 years beginning in 1988.

Pursuant to the provisions of Act 296, SLH 1983, a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal subzones was made. This report addresses the various factors as given below:

1. The area's potential for the production of geothermal energy;

2. The prospects for the utilization of geothermal energy in the area;

3. The geologic hazards that potential geothermal projects would encounter;

4. Social and environmental impacts;

5. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

6. The potential economic benefits to be derived from geothermal development and potential related industries; and

7. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board shall consider, if applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226.

<u>Title 13, Chapter 184</u>

In accordance with Chapters 91 and 205, Hawaii Revised Statutes, and Act 296, SLH 1983, public hearings on the "Proposed Rules for the Designation and Regulation of Geothermal Resource Subzones" were held on May 22, 1984, on all islands by the State Department of Land and Natural Resources.

These proposed rules, formally adopted on July 13, 1984, describe the procedure for initiating the designation of subzones, establishing criteria, providing for the modification and withdrawal of existing subzones, and providing for the regulation of geothermal resource subzones.

Act 151, Session Laws of Hawaii 1984

On May 25, 1984, Act 151, SLH 1984, was signed into law by Governor George R. Ariyoshi. This Act clarifies the rights of existing lessees holding geothermal mining leases issued by the State or geothermal developers holding exploratory and/or development permits from either the State or County governments. Act 151, SLH 1984, also clarifies the respective roles of the State and County governments in connection with the control of geothermal development within geothermal resource subzones.

Some of the highlights of Act 151, SLH 1984, include:

* Permits geothermal development activities within urban, rural, agricultural, and conservation land use districts.

* Defines geothermal development as "the exploration, development or production of electrical energy from geothermal resources."

* Existing leases within an agricultural district which were issued a special use permit by the County for geothermal development activities, is declared a geothermal resource subzone for the duration of the lease.

* Clarifies the governing jurisdiction of the State and County governments in the geothermal development approval process, and also exempts the permit process from special use permit procedures under section 205-6.

* Clarifies the issuing County agency by defining "appropriate county authority" as the "county planning commission unless some other agency or body is designated by ordinance of the county council."

* Further clarifies the roles of the State and County governments in connection with land use designations, as well as conduct of a permit approval process.

* Mandates that the county authority, in the absence of a mutually agreed upon extension, must provide a decision on a complete and properly filed application within 6 months.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES

Basis of Assessment

A Geothermal Resource Technical Committee, selected by the Department of Land and Natural Resources on the basis of their specific expertise, examined each area's potential for the production of geothermal energy and the prospects for the utilization of geothermal energy in the area. Due to the complexity of Hawaii's geologic structure and the variable nature of ground-water hydrology and geochemistry, the committee did not rely on just one set of data or a single set of rules. The assessment of potential for each island was based on a qualitative interpretation of several regional surveys conducted in Hawaii during the last 15 to 20 years. It was further noted that the use of probability ranges was more appropriate in assessing geothermal resource, in that probabilities, would be more precise than other subjective wording. A map of the locations examined is provided at the end of this section.

The committee's assessment was based on the following types of geological, geophysical and geochemical data:

1. Groundwater temperature data. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

2. Geologic age. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

3. Geochemistry. Groundwater having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered ground water are anomalously high silica(SiO_2), chloride(Cl), and magnesium(Mg) concentrations. In addition, the evidence

of above normal concentrations of trace and volatile elements such as mercury(Hg) and radon(Rn) may indicate leakage of geothermal fluids into nearby rock structures.

4. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of ground water. Therefore, rocks saturated with warm saline ground water have lower resistivities than rocks saturated with colder ground water.

5. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above ambient ground temperatures.

6. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

7. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered have substantially lower magnetism than normal rock strata.

8. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

9. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

10. Self potential. Self potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea east rift.

Hawaii County

Upon evaluation of currently available geotechnical data, the Geothermal Resource Technical Committee identified nine locations on the Island of Hawaii and assigned a percent probability of finding low temperature (less than 125°C) resources and high temperature (greater than 125°C) resources at depths less than 3 kilometers. These locations and summary findings are as follows:

Location	Low Temperature	High Temperature
1. Kawaihae	45% or less	less than 10%
2. Hualalai	70% or less	35% or less
3. Mauna Loa Southwest Rift	60% or less	35% or less
4. Mauna Loa Northeast Rift	60% or less	35% or less
5. Kohala	less than 10%	less than 5%
6. Mauna Kea Northwest Rift	less than 50%	less than 20%
7. Mauna Kea East Rift	less than 30%	less than 10%
8. Kilauea Southwest Rift	greater than 90%	greater than 90%
9. Kilauea East Rift	greater than 90%	greater than 90%

Maui County

Within the County of Maui, six locations on the Island of Maui were identified, as well as the Islands of Molokai and Lanai. The Island of Maui has three potential geothermal resource areas. A summary of the locations within the County and the estimated percent probability of finding a low and high temperature resource is given below:

Location	Low Temperature	High Temperature
1. Olowalu-Ukumehame Canyon	75% or less	less than 15%
2. Lahaina-Kaanapali	less than 5%	less than 5%
3. Honolua	less than 5%	less than 5%
4. Haleakala Southwest Rift	35% or less	25% or less
5. Haleakala Northwest Rift	less than 10%	less than 5%
6. Haleakala East Rift	35% or less	25% or less
7. Molokai	less than 5%	less than 5%
8. Lanai	less than 5%	less than 5%

City and County of Honolulu

The Island of Oahu is made up of two major volcanic edifices: the Waianae shield and the Koolau shield. Both locations were determined to have a low probability of finding either a low or high temperature geothermal resource. The summary findings are provided as follows:

Location	Low Temperature	High Temperature
1. Waianae Volcano	15% or less	less than 5%
2. Koolau Volcano	less than 10%	less than 5%

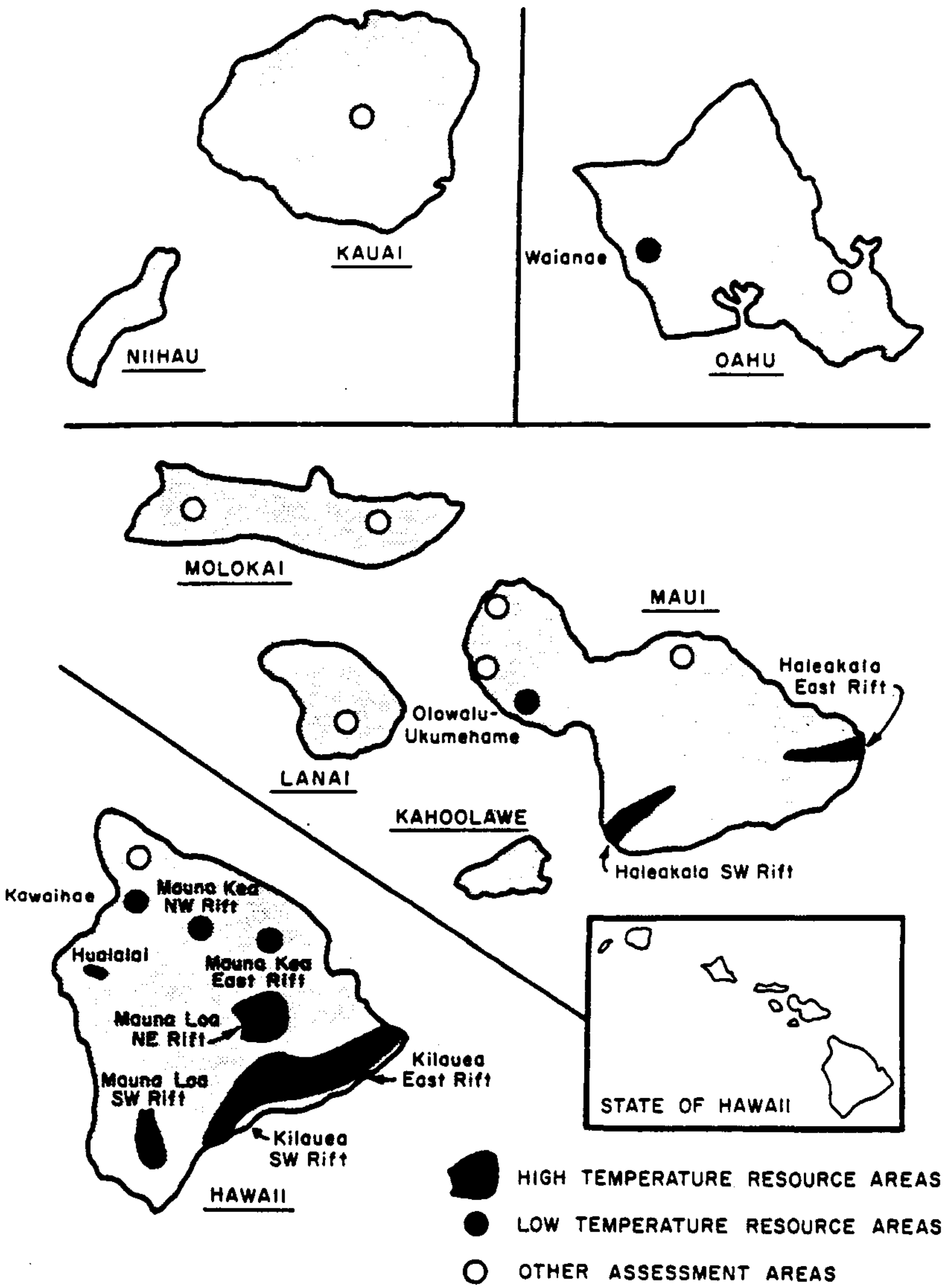
Kauai County

On the basis of currently available information, the geologically old age of Kauai's volcanic activity and the absence of any significant geothermal related anomalies, the probabilities for a geothermal resource are as follows:

Location	Low Temperature	High Temperature
Island of Kauai	less than 5%	less than 5%

Figure 5.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES



GEOTHERMAL TECHNOLOGY

Geothermal Wells

Drilling Depth. In Hawaii, geothermal reservoirs are expected to occur 4,000-8,000 feet below sea level. The rotary drilling rigs likely to be used in Hawaii are rated for drilling to a maximum depth of about 16,000 feet. Some mainland oil-rigs can drill to 22,000 feet but are not considered economical when applied to geothermal development in Hawaii.

Directional Drilling. A geothermal rig can drill a hole perpendicular to the ground surface or directional holes to almost any desired angle from ground surface. A moderate curve in the drill route can also be achieved. Directional drilling can reduce both environmental and economic costs by allowing multiple holes to be drilled from one drill site. However the most economic and shortest route for a drill hole is usually straight and perpendicular to the surface.

Drill Hole Casing. The typical drilled hole has a 26 inch diameter for the first 250 feet, tapering to an eight inch diameter bottom hole in the production zone. The usual casing program includes a conductor pipe (surface to 250 feet), surface casing (surface to 2500 feet), intermediate casing hung from the end of the surface casing (2500 to 4000-6000 feet), and possibly a production liner hung from the end of the intermediate casing to the bottom. All joints should be cemented and joined to ensure casing integrity into the production zone. Available well control techniques and blow-out prevention equipment can substantially reduce the risk of well blow-outs.

Drill Site Surface Area. A 2/1 ratio of good to bad wells is expected in a proven resource area. Once a successful well is drilled, six closely spaced wells (four expected successful) may be drilled within a radius of 2000 feet of the drill site. Two acres of land would be cleared for an exploratory hole. Approximately five acres of land would be cleared on a proven drill site. Four successful wells (three and spare) may be needed for a 12.5 megawatt (MW) plant. Generation capacity can vary from three to ten MW per well depending on the output rate and type (water or vapor dominated) of geothermal resource. The HGP-A test well is producing about three MW; however commercial wells are expected to have a larger capacity. Unsuccessful or expended wells would be abandoned unless used for injection of geothermal effluent.

Drilling Emissions and Effluents. Depending on geologic structure and capability of drilling equipment, either "drilling mud" or air will be used to remove cuttings and lubricate the drill bit. Drilling activities may use 2000 barrels of water per day per well. The mud and cuttings are disposed of at a drill site sump but can be removed to an approved disposal site if required. In the production zones, air drilling (instead of mud) may be used to avoid reduction of permeability in the production zone. While in the production zone, the return-air will contain cuttings and geothermal gases (most significant being H_2S). A caustic soda (NaOH) injection system and cyclone muffler can be used to abate hydrogen sulfide (H_2S), particulates, and noise during drilling. After completing the well, four to eight hours of unabated venting may be required to clear the hole of rock debris. Completed wells will be subjected to flow testing to determine reservoir characteristics. Emissions must meet Department of Health (DOH) standards. If the well is water dominated, a flash separator may be used at the well site to return brine to either a nearby percolation pond or re-injection well.

Injection Wells. One injection well may be needed for the three active wells which may be required to fuel a 12.5 MW plant. The number of injection wells will vary depending on the permeability of the injection well and the quantity of brine flowing from the production wells. The initial injection wells (specifically drilled for injection) are likely to be close to the power plant to limit brine piping distance. Non-producing or expended production holes may also be used for injection. Geothermal effluents will be injected into a geothermal aquifer having similar characteristics. Drill casing intergrity through overlying fresh water aquifers is essential if usable water supplies are to be protected. Injection wells are subject to standards and regulations of the State Department of Land and Natural Resources and Department of Health.

Steam Piping

The steam piping from well-head to plant is likely to be 16 to 22 inch diameter carbon-steel pipes. Piping may be placed four to six feet above ground-level on "saddles" which may be fortified to accomodate pahoehoe lava flows. Alternatively, piping may be buried for safety and aesthetics. The piping will have expansion joints which will allow for thermal expansion and some ground movement. Surface area needed for a pipeline corridor is discussed in the section titled "Roads".

Geothermal Power Plants

Operation. Before a plant becomes operational the Department of Health must issue permits regarding the quality of the air and fluids discharged from the plant. Components of this system are described below.

The characteristics of the geothermal fluid may vary from site to site. It may be liquid or vapor dominated. A vapor dominated system provides more steam for power generation per hole while reducing the amount of brine which must be injected back into the ground. HGP-A is a water dominated system. Kapoho wells #1 and #2 have been reported to be vapor dominated.

As the geothermal fluid enters the power plant the steam and brine components are separated in the "separator". Various heavy metal concentrations such as arsenic, lead, and mercury are very low (based on HGP-A data) and should remain in the brine that is eventually re-injected. The steam phase leaving the seperator consists of primarily water vapor and noncondensable gases. The two most significant noncondensable gases at HGP-A are H_2S and Radon 222.

As described below, the level of H_2S can be almost completely abated. Outdoor concentration levels of emitted radon, if properly abated by dilution in the cooling tower, are lower than most indoor levels; since cement emits some radon in most buildings. Again, the composition of fluids and gases are likely to vary within each reservoir.

The steam phase from the separator enters the turbine, turns the rotors, and exhausts into the condenser. Electricity is produced as the turbine spins the generator. The steam flow and resultant turbine-rotor turning is enhanced by the vacuum created in the condenser as the steam is condensed into liquid. This liquid (condensate) returns with the warm condenser cooling water to the cooling tower where it is cooled by evaporation. The size of the steam plume will vary with the size and efficiency of the plant and the ambient weather characteristics.

Emission Abatement. The gas phase which exits the condenser consists primarily of the same noncondensable components which left the seperator, most notably H_2S. An abatement system is utilized at this point to reduce the H_2S content to an acceptable level. A report recently prepared for the U.S. Environmental Protection Agency, Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, analyzes most available H_2S abatement systems. These include the iron catalyst primary system; the iron catalyst secondary system; the hydrogen peroxide, caustic, iron catalyst (HPCC) primary system; burner-scrubber system; and the Stretford system. The report recommends the Stretford system as the primary on-line abatement system. This system can remove over 99% of the H_2S contained in the noncondensable gases. By-products of the Stretford system include marketable elemental sulfur and sludge which requires disposal.

A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement systems can be utilized in the event the plant is "down" for maintenance or emergency. If maintenance is required on either the turbine or generator, the geothermal steam can be routed directly into the condenser utilizing the primary abatement systems. Since the turbine does not dissipate any heat or energy in the bypass mode, the cooling system must be over-designed to accomodate the extra heat during "turbine bypass". If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal. In emergencies, well throtting may be accomplished by manual valve turndown or automatic valve control. Throtting must be slow (at least 15 minutes) and can reduce flow to a fraction of the well's maximum flow rate. The degree of throtting possible will depend upon the characteristics of each well. However, there is a danger that the additional stress with increased pressure could damage the well-bore, casing, or well-head equipment. If a geothermal developement has more than one power plant, the wells could be moderately throtted and diverted to an operating plant. If all the above contingency abatement options are not available, a geothermal well may have to be free vented through a silencer without H_2S abatement until such time as the well can be shut-in completely.

The abated gases, condensate, and warm water are circulated through the cooling tower. Cooled water from the cooling tower is recirculated through the condenser; any excess water (blowdown) is piped to an injection well. It is expected that a wet, mechanical draft, cooling tower will be applied to geothermal development. Warm water enters the tower near the top, while a fan forces air through slats designed to maximize the surface area of the falling warm water. Use of drift eliminators significantly reduces the chance that any water droplets will exit with the steam plume. This falling water also scrubs any particulates from the gas exiting the abatement system. At "The Geysers" geothermal development in California, small amounts of boron from the condensate has been emitted with cooling tower drift (small water droplets entrained in the the steam plume) having some adverse effects on nearby vegetation. Based on the characteristics of the HGP-A reservoir fluids and the emission abatement which will be required by the DOH, cooling tower emissions from Hawaii's geothermal resources should not be toxic to flora and fauna in the vicinity of the geothermal power plant. Data available from the HGP-A indicates that the plume from the cooling tower should consist entirely of water vapor. The proposed DOH regulations require 98% H_2S abatement and a concentration of no greater than 25 parts per billion H_2S at the property line of a development.

In addition to cooling tower blowdown, brine leaving the seperator will be piped into the injection well. If the rate of silica deposition in the brine is high, a silica-dropout system will be utilized between the steam-brine seperator and the injection well. Otherwise, silica deposition within the injection well might cause it to become plugged. The silica deposits will be removed periodically and disposed of in an acceptable manner.

Plant Site Surface Area. The surface area required for a power plant varies with its megawatt output. By using 12.5 or 55 MW power plant units in tandem, a 25 MW or 110 MW facility can be constructed without increasing the land area of the plant site significantly. Generally, a 12.5 or 25 MW plant will have structure dimensions of 90 feet x 40 feet x 54 feet high (per 12.5 MW unit) sited on a surface area of about 7 acres. A 55 or 110 MW plant will have structure dimensions of 350 feet x 80 feet x 75 feet high (per 55 MW unit) sited on a surface area of about 15 acres.

Roads

Roads must be constructed to accomodate geothermal exploration, development, and production activities. Their placement should avoid volcanic hazards as much as possible. The extent of road building activities at a particular location will be influenced by the existing road infrastructure. Road designs must be submitted to the counties for construction permit approval. Approximate road dimensions are given below:

	Width (ft.)	Height (ft.)	Description
Initial access	20	--	One lane with shoulders.
Main access with transmission lines	78	76*	Two lanes, shoulders, & transmission lines on both sides
Well field road	30	4-6**	One lane, shoulders, dual pipeline corridor on one side

*Electric transmission line poles.
**Steam piping height.

Electric Transmission Lines

Construction of a new transmission line corridor is required to connect the geothermal power plant to the existing power grid. Considering the existing power grid on the island of Hawaii, it appears that the need for new power line corridors will be minimal. However existing lines may need to be upgraded. A 69 kilovolt power line is about 70 feet high and requires a cleared corridor about 70 feet wide. A 138 kilovolt power line is about 80 feet high which requires a corridor of about 80 feet. Dual lines will be used to assure reliability.

Noise Levels and Abatement

During the initial phases of field development, persons in the immediate vicinity of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site. High noise levels are produced during well drilling, production testing, and bleeding before connection to the generator. Drill rig noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise. The above noise levels apply to the immediate vicinity within 100 feet of the source.

The County of Hawaii geothermal noise level guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted.

The design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. Noise will vary with weather conditions and topography. Technology exists which should abate noise to acceptable levels.

Hazard Mitigation Plans.

Various methods which could be used to mitigate dangers from geologic hazards are listed below. No attempt is made to prioritize methods since priorities may differ with the risks at each specific site. A survey should be conducted at each development site to closely examine topography and structural integrity of the surface and sub-surface areas.

- o Keep the power plant as far outside the rift zone as is possible since volcanic activity is concentrated there, e.g. lava flows, lava tubes, cracking, subsidence, pit craters, grabens, swelling. The piping distance from the well field to the power plant is limited due to increased thermal losses with distance, for example, the Kahauale'a site development map shows a maximum distance of about 2½ miles from its farthest well to a power plant.
- o Power plants and wells should be constructed on the highest ground available. Even a very small hill or ridge could offer considerable protection from lava flows. Channels and valleys should be avoided, even if upslope, as lava flows tend to be channeled into and be deepest in these relatively low areas.

- If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from flow hazard, wells or plants can be sufficiently fortified to withstand almost any lava flow. A cost/risk analysis would have to be made.
- Another well-protection alternative is to enclose the well-head in a concrete cellar allowing the lava to flow above rather than around the well-head. Recovering a well covered with a thick flow could be quite arduous and time consuming. The precise effect the lava's heat would have on the well-head mechanisms is not known.
- To complement the platform, a berm or wall could be constructed to divert lava flows. The embankment should be several meters high around the upslope and cross-slope sides of the structure.
- Available information indicates that the northern flank of Kilauea's rift zones are safer than the southern. For example, ground movements are more frequent on the Kilauea east rift zone's southern flank. The vast majority of erupted lava on Kilauea's rift zones has flowed over the southern slopes.
- A geologic survey may identify near-surface lava tubes which could collapse under construction.
- Power plants should be modular and somewhat portable so that, if all fortifications fail, units might be salvaged and reused. This tends to encourage use of smaller decentralized plants.
- Steam transmission piping may be protected from a thin, fluid pahoehoe flow by installing downslope support structures. Thick aa flows would probably disrupt surface piping. Underground piping may offer more protection but installation and maintenance would be quite costly.
- Comprehensive evacuation plans should be designed to assure worker safety. Warning time prior to inundation can be as little as one hour. Procedures should be established to protect equipment. Multiple access roads should be provided in the event one gets covered by a flow.
- The development should coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory)

and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. The developers have been giving this area much consideration.

- o If a lava flow is impending during well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing portion of the well. These plugs can be installed in one hour.
- o Trip wires, placed in the expected path of a lava flow, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan.
- o Protecting structures or machinery against damage by pyroclastic fallout might be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong, having a sufficient pitch so that pyroclastic fallout does not accumulate. Access to roofs should be easy so that, if necessary, they can be manually kept cleared of pyroclastic material.
- o Plant generators can be specifically designed to be adjustable to some ground surface tilting or subsidence.
- o Steam transmission piping can be made with expansion joints to accommodate appreciable subsidence and ground movements.
- o Plants should be constructed to withstand an earthquake of 7.5 magnitude.
- o Power plants should not be constructed in coastal regions, if risk from tsunami is to be avoided.
- o In extraordinary situations, bombing a lava channel may cut the feed to a flow-front and prevent or slow further advance of the lava flow.
- o If warranted by volcanic risk, adequate spacing between developments should be maintained so that one eruption would not likely endanger more than one development. It is a common utility practice to maintain reserves sufficient to prevent a major blackout. Reserve requirements and associated costs may be limited by using small decentralized power plants rather than one large plant.

- o If geothermal development investors assume all of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity.
- o It is generally assumed that the resource developers will bear the risks of loss associated with their activities. However, if the utility owns the power plant, there may be some question as to whether the investors or the rate-payers will bear the risks of loss. This assumption of risk would be reflected in the cost of electricity from geothermal plants. It may be better that this cost be apparent "up front" rather than be delayed and possibly deferred to rate-payers in the event of a catastrophe. In the past, there have been some instances where hazard losses were recovered by the utility from rate revenues (e.g. Hilo tsunami of 1960). Policy regarding assigning and clarifying risks of loss may be implemented by imposing conditions to be met by development investors prior to the granting of a CDUA permit by the State (conservation district) or geothermal resource permit by the County (urban, rural, or agriculture districts).

ASSESSMENT FACTORS

Pursuant to Act 296, SLH 1983, and Act 151, SLH 1984, each of the potential geothermal subzones was examined to determine whether any significant impacts would occur if geothermal development activity would take place. The factors examined included social impacts, economic impacts, environmental impacts, geologic hazards, and compatibility of development with land uses. In addition, the objectives and policies of the Hawaii State Planning Act, Chapter 226, HRS, relating to energy generally and geothermal resources specifically were also examined. This assessment was based on currently available information. This chapter describes the various assessment factors, which were considered in evaluating its significance for designating geothermal resource subzones.

Hawaii State Planning Act

Act 296 specifies that the Board of Land and Natural Resources shall consider the provisions of Chapter 226, the Hawaii State Planning Act. Several provisions of Chapter 226 applies to energy, generally, and with geothermal resources in particular. Excerpts from the Act are presented to serve as a guide for implemention of legislative overall theme, goals, objectives, and policies.

> "Overall theme. Hawaii's people, as both individuals and groups, generally accept and live by a number of principles or values which are an integral part of society. This concept is the unifying theme of the state plan. The following principles or values are established as the overall theme of the Hawaii state plan:
>
> (1) Individual and family self-sufficiency refers to the rights of people to maintain as much self-reliance as possible. It is an expression of the value of independence, in other words, being able to freely pursue personal interests and goals. Self-sufficiency means that individuals and families can express and maintain their own self-interest so long as that self-interest does not adversely affect the general welfare. Individual freedom and individual achievement are possible only by reason of other people in society, the institutions, arrangements and customs that they maintain, and the rights and responsibilities that they sanction.
>
> (2) Social and economic mobility refers to the right of individuals to choose and to have the opportunities for choice available to them. It is a corollary to self-sufficiency. Social and economic mobility means that opportunities and incentives are available for people to seek out their own levels of social and economic fulfillment.
>
> (3) Community or social well-being is a value that encompasses many things. In essence, it refers to healthy social, economic, and physical environments that benefit the community as a whole. A sense of social responsibility, of caring for others and for the well-being of our community and of participating in social and political life, are important aspects of this

concept. It further implies the aloha spirit--attitudes of tolerance, respect, cooperation and unselfish giving, within which Hawaii's society can progress.

"One of the basic functions of our society is to enhance the ability of individuals and groups to pursue their goals freely, to satisfy basic needs and to secure desired socio-economic levels. The elements of choice and mobility within society's legal framework are fundamental rights. Society's role is to encourage conditions within which individuals and groups can approach their desired levels of self-reliance and self-determination. This enables people to gain confidence and self-esteem; citizens contribute more when they possess such qualities in a free and open society.

"Government promotes citizen freedom, self-reliance, self-determination, social and civic responsibility and goals achievement by keeping order, by increasing cooperation among many diverse individuals and groups, and by fostering social and civic responsibilities that affect the general welfare. The greater the number and activities of individuals and groups, the more complex government's role becomes. The function of government, however, is to assist citizens in attaining their goals. Government provides for meaningful participation by the people in decision-making and for effective access to authority as well as an equitable sharing of benefits. Citizens have a responsibility to work with their government to contribute to society's improvement. They must also conduct their activities within an agreed-upon legal system that protects human rights.

"State goals. In order to guarantee those elements of choice and mobility that insure that individuals and groups may approach their desired levels of self-reliance and self-determination, it shall be the goal of the State to achieve:

(1) A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.

(3) Physical, social, and economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, of caring and of participation in community life.

"Objectives and policies for facility systems--energy/utilities.

(a) Planning for the State's facility systems with regard to energy/utilities shall be directed towards the achievement of the following objectives:

(1) Dependable, efficient, and economical statewide energy and communication systems capable of supporting the needs of the people.

(2) Increased energy self-sufficiency.

(b) To achieve the energy/utilities objectives, it shall be the policy of this State to:

(1) Accelerate research development and use of new energy sources.

(2) Provide adequate, reasonably priced, and dependable power and communication services to accommodate demand.

(3) Ensure a sufficient supply of energy to enable power systems to support the demands of growth.

(4) Promote prudent use of power and fuel supplies through education, conservation, and energy-efficient practices.

(5) Ensure that the development or expansion of power systems and sources adequately consider environmental, public health, and safety concerns, and resource limitations.

(6) Promote the use of new energy sources.

(7) Facilitate the development and use of improved communications technology."

Chapter 226 also establishes an overall priority direction and implementing actions to address areas of statewide concern. Priority actions for energy use and development specified include:

(1) Encourage the development of alternate energy sources.

(2) Encourage development of a program to promote conservation of energy use in the State.

(3) Encourage future urbanization into easily serviceable, more compact, concentrated developments in existing

urban areas wherever feasible to maximize energy conservation.

(4) Encourage consumer education programs to reduce energy waste and to increase awareness for the need to conserve energy.

(5) Encourage the use of energy conserving technology and appliances in homes and other buildings.

(6) Explore possible incentives to encourage the use of alternate energy sources in homes and other buildings.

(7) Encourage the development and use of energy and cost-effieint transportation systems.

The Hawaii State Planning Act also provides for the formulation of Functional Plans in twelve functional areas of services provided by the State government. One such area specified is in the functional area of energy. The State Department of Planning and Economic Development was identified to prepare the Energy Functional Plan. The Act provides that the functional plan shall contain objectives to be achieved and policies to be pursued in the primary field of activity and such policies shall address major programs and the location of major facilities, and shall also contain implementation priorities and actions which may include, but not be limited to, programs, maps, regulatory measures, standards, and interagency coordination provisions.

The following implementing actions relating to geothermal energy are excerpted from the State Energy Functional Plan.

ALTERNATE ENERGY RESOURCE DEVELOPMENT

"B. OBJECTIVE: Accelerate the Transition to an Indigenous Renewable Energy Economy by Facilitating Private Sector Activities to Explore Supply Options and Achieve Local Commercialization and Application of Appropriate Alternate Energy Technologies.

"Hawaii's near-total dependence on imported petroleum, spiraling oil prices, the net outflow of dollars for oil payments, and the political unrest of major oil-producing nations threaten local economic stability and the ability to serve energy needs over time. Support and assistance for private sector activities to develop local energy resources will reduce dependence on the world oil market, improve the State's balance of payments, and thus promote economic development, and increase the number and diversity of employment opportunities.

B(1). POLICY: Investigate and alleviate non-technical (legal/institutional/economic/financial) barriers to alternate energy resource development.

B(1)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Support continued implementation of the State Geothermal Commercialization Program to address and mitigate legal and institutional concerns.

Lead Organization(s): DPED
Assisting Organization(s): DLNR; Hawaii County Planning Dept.
Time Frame: Ongoing
Comments: This program was previously Federally-funded. State support will be needed for program continuation. See action E(1)(a) for additional program components. Recommended near-term activities include: (1) legal clarification of the ownership of geothermal resources; (2) assessment of the desirability of establishing a State of Hawaii geothermal resource area (GRA) in Puna to identify the most probable and acceptable area for future geothermal development; and (3) coordination with appropriate State and County agencies to investigate regulatory and land use permit streamlining for geothermal development.

B(2). POLICY: Facilitate research, development and demonstration activities designed to resolve remaining technical barriers to alternate energy technologies in order to expedite local commercialization.

B(2)(a). IMPLEMENTING ACTION: Continue statewide alternate energy resource assessment studies as appropriate to supplement private sector investigations.

Lead Organization(s): UH: C&C DPW: Hawaii R&D; Kauai OED; Maui Mayor's Office
Assisting Organization(s): DPED; HNEI
Time Frame: On going
Comments: High priority is given to the completion of resource assessments for geothermal energy on Hawaii and Maui; and for wind and insolation throughout the State to develop a data

base for small-scale, dispersed installations. Further assessment of ocean thermal energy resources along Leeward Oahu may also be necessary.

B(2)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Continue geothermal research activities as appropriate to support commercialization efforts.

Lead Organization(s): UH
Assisting Organization(s): HGP-A Development Group
Time Frame: Ongoing
Comments: Continued funding is recommended for the following activities: (1) Kapoho reservoir synthesis; (2) electric and seismic properties of rock systems; (3) corrosion studies; and (4) non-electric applications research."

Social Impacts

Health Aspects. The health aspects of geothermal resource development involve primarily the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds. This section deals with the concerns, perceptions and attitudes of the residents regarding the health aspects of geothermal emissions.

Two community-wide survey studies produced information relating to perceptions and concerns about the effects of geothermal development on elements of physical environment such as air quality. The first was done by a community association in Puna, the Puna Hui Ohana. In this survey, 351 Hawaiian residents in the Puna area were interviewed. The results were prepared in a report, Assessment of Geothermal Development Impact on Aboriginal Hawaiians, published in February, 1982. In response to the question of "What kind of change would geothermal development bring about on the physical environment (noise, air quality, visual environment) of Puna?" Out of the 253 responses, 56 said it was "slightly bad" and 114 said it was "very bad".

The second survey study was conducted for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, by SMS Survey, Inc. The Puna Community Survey, completed in April, 1982, interviewed 778 residents in the Puna area. The study reported only one-fifth of the total survey respondents as mentioning that they felt that they had been affected by the geothermal wells in Puna. Of those indicating they were affected, the negative effects mentioned were "health problems" and "smell".

In addition to these two major survey studies, other inputs made by community associations and other organizations and individuals regarding the HGP-A well and the Kahauale'a Conservation District Use Application are available.

A study is presently being conducted by the Hawaii State Department of Health, on the health status of the Puna population exposed to low levels of hydrogen sulfide and other geothermal effluents. This study surveyed some 135 households in the Leilani Estates representing 350 people and a "control" group of 179 households in the Hawaiian Beaches Estates, representing 604 people, the control population being similar in demographic characteristics to but not having the exposure to geothermal emissions as the Leilani Estates population. A series of close to thirty questions were asked concerning health backgrounds and conditions and problems. Survey data are being processed and analysed and the results are expected by late 1984.

Noise Aspects. Although noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor to be controlled and monitored. In terms of people's perceptions of and concerns with the noise factor, the SMS Puna Community Survey reported that of the 18% who responded "yes" to the question of whether they or their households had been affected by the wells in Puna in any way, 22% mentioned they were affected by "noise".

In May of 1981, the County of Hawaii Planning Department issued a set of Geothermal Noise Level Guidelines to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu and state-wide, based on lower existing ambient noise levels for the Island of Hawaii.

Lifestyle, Culture, and Community Setting. The lifestyle, culture and community setting or atmosphere of an area are very much inter-related and represent a major concern in terms of the effects of any introduced changes, especially when the changes may be in the direction of industrial development in a relatively rural setting. The Puna area has the most information and the input to-date on these aspects in relation to geothermal development may for the time being be applicable to an extent to other localities. Each community, however, will have its own unique background and perceptions and goals. Each community should in the process of considering geothermal resource development contribute its own input into the assessments.

Much about the cultural background, beliefs, practices, and lifestyles of the Hawaiian residents in Puna were reported and discussed in the survey by the Puna Hui Ohana's, Assessment of Geothermal Development Impact on Aboriginal Hawaiians. On attitudes towards the effects of geothermal development, the survey reported "A large number of impacts were perceived as negative by the respondents; and only one, economic impact, was reported to be clearly positive. Yet the question asking about the 'overall' impact of geothermal development in Puna produced responses averaging in the "neither good nor bad" middle ground. There seems to be a balancing of the potential economic benefits of geothermal development with the environmental and social costs of development".

In the SMS study, The Puna Community Survey, respondents asked to name the best things about life in Puna today cited a great variety of factors, with 49% of the factors or items mentioned being in the category of lack of population and development, e.g. country atmosphere, rural area, uncrowded, etc., and 40% of the factors cited in the category of physical environment, and 33% of the elements cited being in the social/lifestyle factors group.

The survey also reported that the greatest divergence among attitudinal responses was between the Keaau and Kapoho-Kalapana planning areas, Keaau residents being the most concerned with economic development and jobs while Kapoho-Kalapana respondents were "suspicious of it". This was analysed in the report to be a function of the uncertainties and anxieties among Keaau residents concerning the closing down of Puna Sugar Plantation, whereas Kapoho-Kalapana's current rural character would be more affected by geothermal-related activities.

Aesthetic Aspects. Although in some areas with potential geothermal resource development the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping.

The SMS study mentioned before, The Puna Community Survey, reported that of the negative impacts perceived relating to the geothermal well, 5% felt that it "looks bad". The area respondents with the greatest percentage of citing of the aesthetic aspect were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance.

Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures and towers and plants with colors to blend in with the natural setting. A 20MW to 30MW plant complex might be given attention and care as a design model for any future expansion that may be considered desirable.

Economic Impacts

As with any economic activity, the injection of dollars into the economy will result in direct impacts through the purchases of various goods and services from the other industries. In the case of a 20 to 30 megawatt geothermal plant, the dollars injected into the economy may be the result of the inflow of investment capital or the dollars prevented from being "exported" from the State or the County in the substitution or displacement of approximately 390 thousand barrels of petroleum each year that would have otherwise been imported into this State for conversion into electricity. The additional purchases made will, in turn, cause these industries to purchase more goods and services from other industries. The result is a chain-reaction of purchases, or a "multiplier" effect produced by the original increase in purchases.

The simpliest way to understand the basics of the multiplier effect is to consider what would happen if one were given a "brand new dollar". It is likely that the person would spend part of it and save the rest. Let's say you spent 80¢ of that dollar. For simplicity, assume that individuals and businesses were equal entities in their economic behavior. If the ratio of .8 was assumed to remain constant, then of the 80¢, 64¢ would be spent and the balance saved. If this process were to continue indefinitely until all the money was either spent or saved in this proportion, the "injection" of this "brand new dollar" would ultimately yield $5.00 in output for our simple economy.

The State's 1977 input-output model's income, output and employment multipliers were used. This model summarized the economic activities of the State at a given moment or period in time, providing information on the inter-relationships between all sectors within the economy. The analysis concentrated on the economic impacts that may result due to the operation of a geothermal plant. It disregarded the impacts which may occur during the construction phases.

The full measure of these impacts may be offset by the degree to which monies used to finance the operations originated locally or outside of Hawaii. Additionally, County conditions may not provide the opportunities that can be found on Oahu, and as such, the full impact of the output generated may not occur. Furthermore, one of the major characteristics of the input-output model used to generate these multipliers is that it implicitly assumes that the structure of Hawaii's economy in terms of the state of technology in 1977 has not changed significantly.

These impacts, especially the total impacts are long run in nature. That is, the subsequent indirect and induced activities do not take place instantaneously, but requires fairly lengthy periods of time for such events to take place, all other things held constant.

The overall assessment is that a 20 to 30 megawatt geothermal power plant will have some economic impact on a State-wide and County-wide basis, but the impact would probably not be significant. Based upon the data available, the direct wages to the 25 direct project employees will be about $560,000 per year. This direct income will stimulate a multiplier effect totalling an estimated $1.3 million. Additionally, an estimated 57 additional jobs will be created.

Public Revenue and Community Resource Analysis. Any economic activity results in certain gains and losses to the economy. In particular, an economic activity provides the public sector with additional sources of revenues and also increases the burden on the available public resources. In order to assess the impact of this project, an estimate of the incremental revenues and costs needs to be made. For the purposes of this analysis, only those major financial impacts likely to occur as a result of this project was considered. Order-of-magnitude estimates of the variables in this section were made where data was available and considered applicable to the assumed 20 to 30 megawatt geothermal plant case study. The estimation of a revenue-cost ratio was omitted at this preliminary stage of analysis.

For simplicity of analysis, it was assumed that all the employees will be brought in from outside the County. This will provide the "worst case" situation. Furthermore, it was assumed that a one-to-one relationship between employee and household exists. Thus, a total of 25 households will become the basis of the analysis. Lastly, it was assumed that all households will reside within the same district as the geothermal site.

Public Sector Revenue. At the County level, three major sources of revenue was addressed in relation to the existence of a geothermal plant. The first is property taxes, followed by fuel taxes and sewer charges.

At the State level, there are four major sources of public revenue that deserves treatment. The first is the general excise tax.

Next, is income taxes, both the corporate and the personal. Finally, the royalty income on the geothermal mineral rights.

Community Resource Analysis. Although the on-site facility will draw upon the community's resources, this section addressed only the probable impacts that may take place due to the increase in population within the immediate community or to the County. The principal resources that will be analyzed includes: housing, lower education, police and fire.

Based upon the scenerio that all 25 workers are from outside the County, the selected sources of revenues to both the County and to the State will not be a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, a more precise delineation of the type of plant, in terms of legal organization and activities, will be required to determine a more accurate public revenue estimate.

Overall, the impact of the 25 additional households to the community will be primarily in the housing market, if all 25 workers are from outside the County. The likelihood of this "worst case" assumption seems to be fairly small. Thus, it is probable that a part of the needed workforce will come from the County and therefore the housing impact will not be as great. Other community resources will not be affected in a significant manner under the current scenerio.

Environmental Impacts

Meteorology. The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise. The most common winds over the Hawaiian Islands are the trade winds from the northeast which account for about 70% of the winds in the Islands. These trades prevail over 90% of the time in June through August and only 40 to 60% of the time in January through March. During the winter, the trade winds are sometimes absent almost an entire month.

The analysis of wind direction was based on the few wind summaries available along the rift zone and interpolation drawn from existing data collected in other parts of the island. Due to the limited amount of available data, earlier written articles were also utilized in the study of the wind patterns over the rift zones.

Testimony at the public information meetings indicated that localized wind patterns from Kahaualea which normally blow into the National Park during the day, sometimes reverses direction at night blowing toward residential communities.

Flora and Fauna. One of most serious potential impacts of geothermal energy development in Hawaii is the disruption of native forests. Air pollution and ground water impacts of geothermal development may be substantially avoided by requiring full control technologies and impacts on native forest ecosystems can be mitigated through careful siting. Siting to avoid damage to biologically valuable forest can prevent both degradation of the forest due to invasion of weed species and disturbance of native bird species due to human activity and noise.

Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas. Once such an invasion begins, native forest is gradually altered, and non-native species, which initally invaded along relatively narrow corridors, spread and multiply. Major geothermal development, with an attendant network of roads and construction corridors, may be expected to dissect and possibly degrade undisturbed native forest by opening it to invasion by weedy species.

Geothermal development may also have potential negative impact on native birds, including many of which are endangered. Construction noise and human activity are factors which favor urban nuisance species over native forest species. It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal energy development. Any development within the habitat of native birds which have potential environmental impact should be fully investigated and mitigation measures implemented.

In selecting areas in which geothermal development will have the least environmental impact, it is therefore useful to assess both forest quality and native bird habitat. Those areas with mature native forest and significant native bird habitat will tend to be the most environmentally important, while those without native bird habitat and less intact forest will be substantially less impacted. For this study, indicators were used to distinguish, on a broad scale, areas of high and low potential environmental impact. For the present assessment, two indicators have been chosen, one of native habitat importance and one of forest quality.

The indicator chosen to depict the value of an area to native fauna is the presence of endangered species. While under some circumstances a simple survey for endangered species is an unacceptably superficial form of environmental assessment, in the present situation the presence of endangered species correlates quite well with the value of the area to native fauna in general. Relative value of native forest has been assessed using a categorization system developed by the University of Hawaii Environmental Center based on forest type mapping done by the United States Fish and Wildlife Services. This system indicates areas in which geothermal development would have the greatest environmental impact, areas in which geothermal development would have little or no impact on valuable native forest, and areas in which the impact of geothermal development on native forest is uncertain.

For the present assessment, endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are plans of action for restoring the population of a species pursuant to its listing as endangered by the Secretary of the Interior. Recovery plans are drafted by teams of wildlife experts from both State and Federal agencies, and represent estimates of the range and life requirements of endangered species by the foremost experts in the field. Essential habitat outlined in an Endangered Species Recovery Plan is therefore almost without exception the most authoritative estimate of the actual habitat for a particular endangered species. Where no essential habitat has been designated, distribution was determined from population surveys condected by the U.S. Fish and Wildlife Services or other available information. Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow (Alala) on the Island of Hawaii and for the Nene on both Maui and the Big Island. Essential habitat has not been determined for the endangered Maui forest birds, and therefore U.S. Fish and Wildlife Service population counts were used to determine habitat boundaries for these species.

The potential for environmental impact on the flora of the resource areas was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping. The U.S. Fish and Wildlife Service system incorporates information on extent of canopy cover, height of canopy, understory composition, and vegetation association by type. Vegetation information has been assembled and mapped by U.S. Fish and Wildlife Service using this system for large portions of four of the five main Hawaiian Islands, including Maui and Hawaii. Information in this form was available to the present study for all or portions of each of the resource areas. Areas not covered were lower Hana, lower Makena, Kilauea S.W. Rift, and lower Puna. In these areas aerial photo interpretation was used to estimate vegetation type, and in high resource potential areas this aerial interpretation was verified on the ground from readily accessible roadways wherever possible. Lack of access routes made ground verification for the Kilauea S.W. Rift site impractical. The boundaries delineated on the aerial photographs were transferred to orthophoto quadrangles and assigned a vegetation type code following the U.S. Fish and Wildlife Service system. Vegetation type data was then ranked according to potential impacts from geothermal development.

Surface Water. Geothermal development activities should not directly affect existing land uses since there are no surface streams located in the recommended areas. While drilling and construction phases of geothermal development may be a cause of concern, little or no environmental impacts are expected. However, if surface water becomes available, accidental pollution of streams should be prevented, and adequate and safe disposal methods of geothermal brine are available.

Almost all geothermal fluids have a total dissolved solids content greater than 1,000 parts per million, and their indiscriminate discharge into streams, ponds, and watersheds should not be allowed. The normal disposal practice is expected to be by reinjection into the geothermal reservoir. In some cases it is possible that byproduct fluids may be of satisfactory quality to be disposed of without treatment. Surface disposal, in these cases, could be allowed under controlled conditions. Environmental impacts on surface waters resulting from the development of geothermal resources in the prospective geothermal subzones are expected to be minimal.

Ground Water. Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water.

Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations.

Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes, water is held between the dikes to a height of more than 2,000 feet above sea level.

Basal water occurs most commonly in the islands. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. In the areas considered, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the groundwater aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions, and alternate safe disposal methods should be developed.

Air Quality. The assessment of air quality impacts resulting from geothermal development requires examination of ambient air quality along active rift zones, emissions from geothermal wells and power plants and the current level of geothermal emission abatement technology.

Geothermal developments in Hawaii will be required to have abatement systems that meet the proposed State Department of Health air quality standards. At present, the recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the non-condensable gases. Use of this system would enable facilities to comply with the proposed air quality standards that require 98% of the H_2S present to be removed.

It should be noted that due to the sulfur content of fuel oil, oil-fired power plants may emit at least ten times more sulfur dioxide per megawatt-hour than would a geothermal power plant. Therefore, replacement of oil-fired power plants with geothermal power plants may reduce the overall impact to the environment and air quality.

Two major sources of recent information that help answer the questions and concerns are: Environmental Baseline Survey, Kilauea East Rift, Puna and Ka'u Districts, County of Hawaii (Final Report, 1984), prepared for the Hawaii State Department of Planning and Economic Development by NEA, Inc., in which definitive additional information on ambient air composition was obtained; and Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, January, 1984, prepared for the U.S. Environmental Protection Agency by Dames & Moore.

In its conclusions on the air quality impact of potential geothermal development in Hawaii, the Dames and Moore study reports the following, based on the Best Available Control Technology (BACT) for emission abatement:

> "H_2S, particulate and trace element emission rates were all developed from data gathered at HGP-A and assuming the emission controls described above. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality. Based on

these calculations, potential H_2S emissions during normal power plant operations for the development scenarios [25MW and 50MW] described in this report are well below the proposed Hawaii ambient air quality standard (HAAQS) for H_2S. However, H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emissions control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities.

"Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds."

Cultural and Archaeological Values. Cultural values refer to the range of historical activities carried out by early Hawaiian residents. Archaeological values refer to all structures and artifacts that provide evidence of early habitation.

The Hawaiian land use concept of the ahupuaa is most useful in understanding the range of activities likely to occur within a subzone area, as well as the potential for archaeological sites within a subzone. For example, early coastal fishing villages often had inland agricultural fields. In addition to fishing and farming, various forest products were harvested from mauka or upland areas (koa for canoes, pulu for stuffing, ohia logs, birds for feathers) and early trail systems connected remote villages.

Evidence of these activities found in remaining archaeological sites is critical to reconstructing Hawaiian history and pre-history.

Geothermal development may potentially degrade such remaining evidence by site clearing and facility construction.

Estimates of the likely impacts of geothermal development can be accomplished by (1) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, (2) by plotting the location of known archaeological sites within or nearby proposed subzones, and (3) by on-site archaeological reconnaissance surveys.

Two literature searches were prepared for the Kahaualea EIS. A similar search accompanied by maps showing known sites could be prepared for each subzone area.

Scenic and Aesthetic Values. Scenic and aesthetic values, in general, refer to landscape qualities likely to be impacted by geothermal development. Since most sites with geothermal potential are located in remote wilderness areas and are often heavily forested, development of geothermal facilities represents a visual intrusion.

The potential sources of visual intrusion include: clearing forested areas for construction, the temporary presence of drilling rigs, night lighting of drilling rigs, permanent presence of power plant structures with cooling towers (50 to 65 feet in height), geothermal fluid transmission lines, electrical transmission lines (70+ feet in height), and a periodic presence of steam plumes above well heads and power plant cooling towers (under certain climatic conditions, steam plumes may rise to 150 to 200 feet above the site).

Estimates of visual impact are accomplished by preparing an area-wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc. can be seen. In preparing a terrain analysis of visual impacts, various observer location points are selected and view lines calculated at each site. The observer is assumed to have an eye level 10 feet above ground surface and power plant height is assumed to be 80 feet above ground level. Profiles or visual perspectives are constructed to show the view lines from each observer location to a proposed power plant location. From such a profile, it is possible to determine the extent to which a site is visible from each observer location.

Geologic Hazards

General. The same volcanic activity which provides the source of geothermal heat may also create a hazard to people and property. Volcanic hazards include lava flows, pyroclastic fallout, ground deformation, cracking, and subsidence. With proper evacuation planning, lava flows should not be a great danger to people because of their usually slow speed and somewhat predictable paths, however, substantial property damage is a possibility. The table below summarizes past eruptive activity.

Historic Eruptions Within Geothermal Resource Areas

Location	Number of Eruptions Since 1750	Average Area (km^2)
Kilauea Upper East Rift*	21	6
Kilauea Lower East Rift*	5	11
Kilauea Southwest Rift	5	7
Mauna Loa Northeast Rift	7	37
Mauna Loa Southwest Rift	7	34
Hualalai	1	46
Haleakala Southwest Rift	1	6
Haleakala East Rift	0	--

*An imaginary line extending approximately north of Kalapana distinguishes the lower and upper east rift zone. Caldera eruptions were not considered.

A significant phenomenon is unique to Kilauea: the southern flanks of its rift zones are much more prone to be covered by lava flows than are the north flanks due to topography.

Several mitigation methods are available which may reduce the risk from geologic hazards. These methods include strategic siting, special construction designs and fortifications, evacuation planning, decentralization of power plants, and giving development investors a clear economic incentive to utilize mitigation methods by having them assume all the associated risks of loss.

In the past, several attempts have been made to restrict the flow of lava in Hawaii, Italy, and Iceland. These examples illustrate the effectiveness of the technology used and the costs involved. In those situations, governmental authorities spent large amounts of money, sometimes millions of dollars, in efforts to protect communities threatened by lava flows.

The past history and nature of geologic hazards can provide a valid guide to the probable course of future activity, although it is not possible to detail the specific time and location of such activity.

Lava Flows. Lava flows generated during volcanic eruptions and can cover extensive areas extending out to more than 10 kilometers from the source, be it a vent or long linear fissure or crack. Lava tends to flow freely and the course taken by the flow is fairly predictable since it is determined by ground slope. However, ridges built by cooling lava on the sides of a flow may create channels and alter the lava flow direction. Flows from earlier phases of an eruption can quickly change the topography and expected course of the flow. In a somewhat similar manner, other natural and man-made obstacles can divert lava flows.

Lava flows vary in their flow behavior. Thick distal aa flows tend to bulldoze, crush, bury, and burn any surface structures in their path. The more fluid, newly erupted, proximal (near-vent) lava tends to flow around obstacles. A fluid flow could enter buildings and may not cause much structural damage beyond igniting flammable materials and softening and distorting some of the metalwork. In principle, fluid pahoehoe lava can subsequently be removed and the building reoccupied. In principle this would also apply to flows covering protective well cellars and thin pahoehoe flows surrounding transmission piping. However, recovery from a deep or long duration flow could take many months.

Pyroclastic Fallout. Explosive high-output eruption fountains may eject rock fragments of many types and sizes. The fallout range can be appreciable as far as 500 or 1000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones and may be tens or hundreds of feet thick. Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent.

The probability of an eruption being potentially explosive (with resultant increased debris) increases as the coast is approached and is near 100% for a vent within about 1 kilometer of the coast. Steam from the near-surface water table promotes such explosiveness.

Other dangers from fallout include lung irrigation, poor visibility, anxiety or panic, blockage of escape routes, and severe cleanup problems.

Ground Cracks. Cracks which may open as much as several feet, can be the surface expression of dikes that fail to reach the surface. These cracks can produce a surface graben in which the ground subsides between two parallel cracks. This type of cracking related to magma movement is concentrated in volcanic rift zones which are narrow and clearly defined. Cracks could possibly open outside a rift zone; however, not enough information is available to assess the probability, which is considered to be low.

Ground cracking can also be associated with tectonic earthquakes. Their formation is often accompanied by a relative vertical or lateral displacement of the ground on either side. Tectonic ground cracking is usually localized in definable zones.

Ground cracking across a geothermal plant could cause a suspension of operation, depending on the extent and location of damages.

Pipes carrying steam between the wells and plant are unlikely to be damaged by minor ground cracking, since they are designed with expansion joints at regular intervals.

Ground cracking close to a well bore might open up an alternate path for the steam and cause its loss from the well. This is unlikely due to the vertical pitch of most cracks. However, in the event a crack does intercept a well bore several things might happen. If the crack is below the local water table, water could rush into the bore and seal the release of steam by hydrostatic pressure. If the crack is above the water table, steam could escape into the surrounding rock strata. If the crack is close to surface, steam could escape and vent its way to the surface. In the latter event, a cement plug poured from an intercepting directional drill hole may seal the leak.

Ground Subsidence. Subsidence from geothermal fluid withdrawal is not likely to be problem; since the islands are generally comprised of dense, permeable, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which usually occurs on or about active rift zones, e.g. Kilauea.

Small to large grabens may result from the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks.

Subsidence and cracking may also be associated with tectonic earthquakes, e.g. subsiding slump blocks along the Hilina fault system near Kilauea.

Collapsing pit craters and lava tubes can result in very severe localized subidence. Pit craters usually occur within a summit or rift zone of a volcano. Fragile, near-surface lava tubes (usually found in pahoehoe flows) are subject to collapse from heavy surface activity. A geologic site-survey could identify these hazards.

Aside from the immediate effects subsidence may have on the foundation and contents of a power plant, subsidence also increases the hazards from lava flows since flows usually seek lower areas.

Earthquakes. Most earthquakes in Hawaii are volcanic in nature, resulting from the vibration of near surface magma movements. They usually cause little direct damage. Larger earthquakes tend to be tectonic, generally resulting from the movement of large rock bodies.

Major earthquake shaking can potentially damage poorly constructed buildings. Indirect damage may also be caused by smaller, more common volcanic earthquakes. Experts have recommended that development facilities be constructed to withstand shaking from a 7.5 magnitude earthquake. The largest earthquake in the State occurred on the island of Hawaii in 1868, having a magnitude of 7.5.

Tsunami. Tsunamis are large sea waves usually generated by movement of large submarine rock masses or volcanic eruptions. These waves can travel great distances at speeds of almost 500 miles per hour and move on shore turbulently or merely rise quietly.

The tsunami hazard is probably localized to a zone of land approximately 2 kilometers wide along the coast, and at elevations not much higher than 75 feet. This is not expected to pose a significant danger to geothermal developments which are likely to be situated at higher elevations.

Compatibility with Land Uses

State Land Use Classification. Under the provisions of Chapter 205-2 of the Hawaii Revised Statutes, Districting and Classification of Lands, there are four major land use districts in which all lands in the State shall be placed: (1) urban, (2) rural, (3) agricultural, and (4) conservation.

Urban districts shall include activities or uses as provided by ordinances or regulations of the county within which the urban district is situated.

Rural districts shall include activities or uses as characterized by low density residential lots of not more than one dwelling house per one-half acre in areas where 'city-like' concentration of people, structures, streets, and urban level of services are absent, and where small farms are intermixed with the low density residential lots. These districts may include contiguous areas which are not suited to low density residential lots or small farms by reason of topography, soils, and other related characteristics.

Agricultural districts shall include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters or dwellings, mills, storage facilities, processing facilities, and roadside stands for the sale of products grown on the premises; agricultural parts and open area recreational facilities.

Conservation districts shall include areas necessary for protecting watersheds and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding communities, or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

The use of an area for the exploration, development and production of electrical energy from geothermal sources within a geothermal resource subzone shall be governed by the Board of Land and Natural Resources within the conservation district and by existing State and County statutues, ordinances, and rules within the agricultural, rural, and urban districts, except that no Land Use Commission approval shall be required for the use of subzones.

In addressing the compatibility of geothermal activity within a conservation district, we must first recognize the various land use districts. There are four major land use districts in which all lands in the State of Hawaii are placed: urban, rural, agricultural, and conservation. The lands designated as conservation have also been labeled conservation under the respective county general and community plans. The conservation area is further divided into five subzones: protective (P), limited (L), resource (R), general (G), and special (SS).

The protective subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. The limited subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the resource subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General subzones are open space where specific conservation uses may not be defined, but where urban use would be premature. Special subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area.

Conservation districts constitute a large percentage of the potential resource areas. Each area within the conservation district has permitted uses. In each of the areas mentioned; protective, limited, resource and general; the use of the area for "monitoring, observing, and measuring natural resources" is permitted. In this respect exploration of geothermal resources can be allowed in a conservation district. The development of these resources within a conservation district which, allows "governmental use not enumerated herein where public benefit outweights any impact on the conservation district" is therefore permitted and can eventually lead to greater Statewide benefit. In managing the uses of conservation lands, careful analysis of the proposed use is required. Thus, only when the benefits of the proposed use is determined to be greater than any repercussions on the land will the use be permitted.

The compatability of geothermal development with the proposed land uses outlined in each respective county's general plan can be determined with respect to the various land use categories. One of the general objectives set forth in the County General Plans is to "protect and encourage the utilization of the County's limited prime agricultural lands" and promote "uses of land meeting the social and economic needs of the people". Thus, careful management of geothermal development in urban, rural and agricultural districts can insure compatability with the broad objectives and policies for long range development of the County.

COMMUNITY CONCERNS

Various channels and methods of community input are involved in the preliminary and future processes of geothermal resource development evaluation and actualization. The community surveys by the Puna Hui Ohana and by SMS Research, Inc. involved resident response and assistance in conducting these surveys.

In a study prepared by Dr. Penelope A. Canan, Assistant Professor of Sociology and Urban and Regional Planning at the University of Hawaii, The Social and Economic Impacts of Geothermal Development in Hawaii, theoretical social impact assessment and management models were suggested and discussed, along with the use of multi-disciplinary groups, "objective" and "subjective" social indicators, the inclusion of the planning process in community process models, and the prerequisite of site specification in social impacts assessment.

Public informational meetings held by the State Department of Land and Natural Resources during the month of May and July, 1984 on the Islands of Hawaii and Maui, encouraged public participation, so that the planning process may include, in the preliminary stage as well as later on in the process, as much input as possible from the public.

Other sources and channels of community input include the planning processes, goals, objectives and development policies formulated and adopted in community plans that become a part of the County General Plans and the State General Plan and its input processes, as well as policies brought forth by representatives of people and communities in the State Legislature.

During the course of the assessment, several public information and participation meetings were held and conducted by the staff of the Division of Water and Land Development. Following are the dates and places of community meetings held:

May 8, 1984	- Hilo, Hawaii
May 9, 1984	- Kahului, Maui
May 29, 1984	- Hilo, Hawaii
May 30, 1984	- Kahului, Maui
July 10, 1984	- Puna Community Council
July 11, 1984	- Volcano Community Association
July 27, 1984	- Ulupalakua, Kanaio, Maui

Island of Hawaii, Generally

Support for geothermal resource exploration, development, and production on the island of Hawaii has been voiced by the Mayor, County Council, Chamber of Commerce, and several communities in the Puna area.

Opposition has been expressed in specific phases of the overall development, such as emissions and noise emanating from geothermal resource activities, but not necessarily with development of geothermal resource energy as an alternate energy source for Hawaii.

Puna Community

Comments recieved at public information meetings in Hilo and at Puna indicate that geothermal resource activities, if done with due regard to local concerns, would not be detrimental to the area.

Volcano Community

Vocal opposition to geothermal resource development were generally expressed at all of the public information meetings. Adverse effects to forests, bird habitats, proximity to the Volcanoes National Park and the lowering of property values were highlighted. The current volcanic flows were cited as a potential hazard to development activities indirectly affecting the safety of nearby communities.

Island of Maui, Generally

Support was also expressed by the Mayor, County Council, Chamber of Commerce and the Maui Electric Company. Opposition was voiced by some residents living in the Ulupalakua and Kanaio areas.

Ulupalakua-Kanaio Residents

Residents of the Ulupalakua and Kanaio areas voiced their concerns at the public information meetings, citing adverse effects on the health of residents and disturbance to rural lifestyle. An arboretum located on the Vockrodt property in Ulupalakua was visited by the staff on invitation by the owners.

EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

Kilauea Lower East Rift, Hawaii

Potentials for Production. Commercially feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9840 feet..

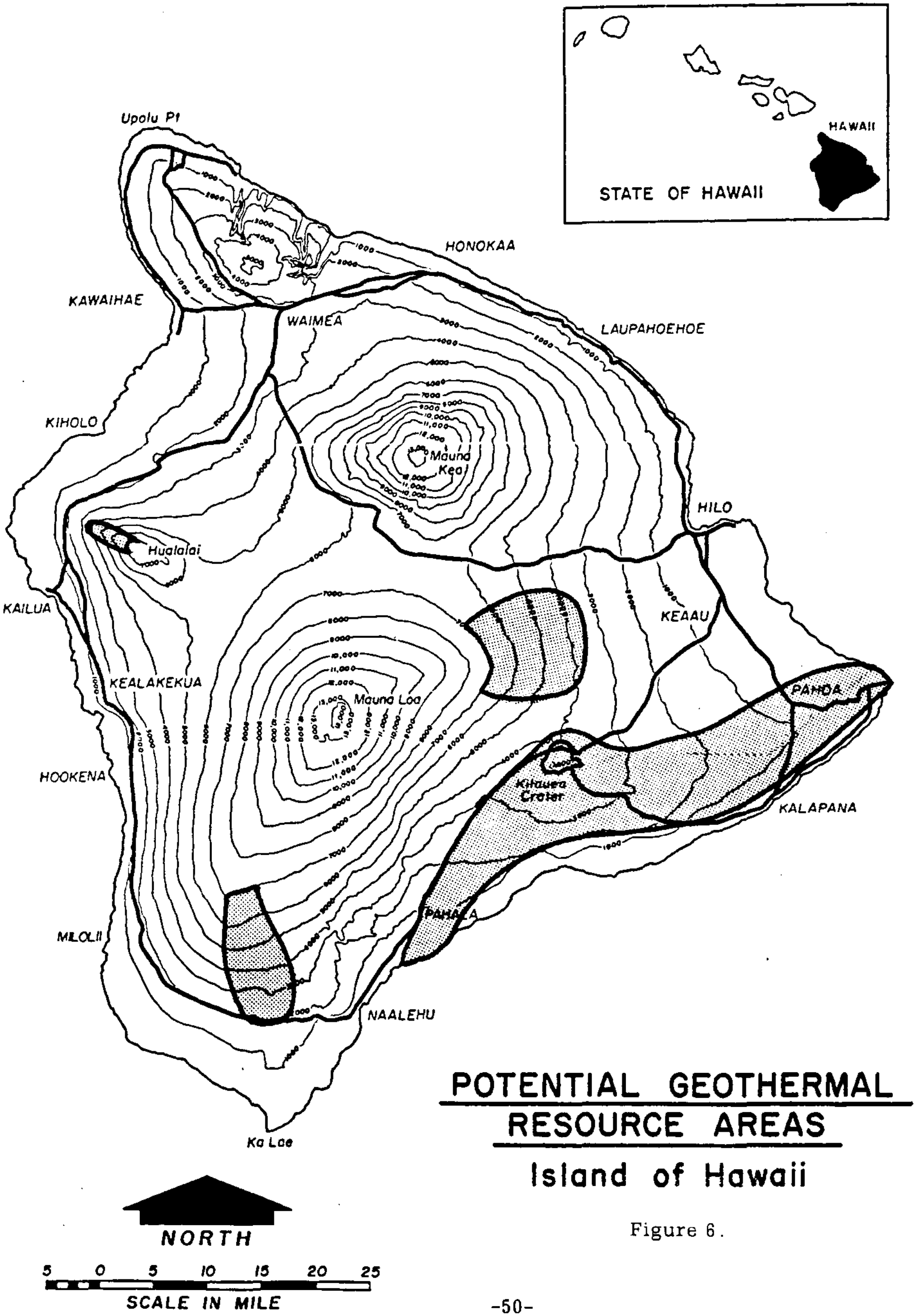
Prospects for Utilization. Based upon prior permit applications and developer activity, the prospects for utilization of both subzones being proposed is considered good.

Geologic Hazards. Historic lava flows have occurred in Kilauea's lower east rift zone in 1750, 1790, 1840, 1955, and 1960. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. There may be some danger from tsunami and ground subsidence in coastal areas.

Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety and productivity.

Social Impact. The principal social factors affected by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in Puna. The impact is expected to be moderate and adverse conditions can be mitigated. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts. The general impact of geothermal development to the environment will be in the areas of noise and air quality. These conditions are to be minimized and adverse impacts



POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Hawaii

Figure 6.

mitigated by utilizing current technological equipment to muffle and filter.

Compatibility of Development. A portion of the proposed Kapoho subzone includes two current Geothermal Resource Mining Leases, R-2 and R-3, which were declared subzones through Act 151, SLH 1984.

The proposed Kapoho subzone rests within agricultural and conservation districts. Geologic hazards as outlined in Chapter 4 can be mitigated and adverse environmental conditions minimized.

The existing HGP-A facility demonstrates that with careful planning geothermal development can be compatible with existing uses in this area.

Economic Impact. Geothermal development within the proposed subzone will provide a measure of energy self-sufficiency and reduce the State's dependency on imported oil for electrical production. In addition, development of geothermal resources will generate added income and initiate additional jobs in the area. The construction industry may benefit should additional housing be needed to accommodate new workers.

Kilauea Upper East Rift, Hawaii

Potentials for Production. Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9840 feet.

Prospects for Utilization. Based upon prior permit applications and developer interest, the prospects for utilization of the proposed subzone is considered good.

Geologic Hazards. The proposed Kilauea Upper East Rift Zone subzone is in an area generally north of the rift zone axis. About 75% of this proposed subzone area has not been affected by historic lava flows. Every historic flow has flowed to the south with the exception of the present Puu 'O' flows. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. Volcanic activity which creates a hazard is also the source of geothermal heat required for power generation. The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana. It resulted in cracking, subsidence, and tsunami.

Geothermal development activities may occur once present volcanic activity ceases. Those areas that have been covered by recent flows are likely to be used for well sites, while safer northern areas are likely to be used for power generation facilities. Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety an productivity.

Social Impact. Social impacts related to geothermal development can be minimized with careful planning. In the volcano area, the principal social factors that may be affected by development activities are in terms of lifestyle, culture and community setting.

The location of the proposed geothermal resource subzone is set back away from the Volcano community, Hawaii Volcanoes National Park boundaries, and the Wao Kele O Puna Natural Area Reserve. The preservation of natural beauty and aesthetics can be achieved by well-planned siting, landscaping, well-designed plant architecture, and proper mitigation measures.

Environmental Impacts. The development of geothermal resources along the Kilauea Upper East Rift Zone will be limited to the proposed subzone area. The general environmental impact from development activities will be in the area of noise and air quality. These impacts are expected to be minimized and adverse conditions mitigated by utilizing current technological equipment to muffle and filter. Air quality within surrounding areas should not be impacted, since given the current level of abatement technology, developers will be required to comply with State Department of Health Air Quality Standards.

While a major portion of this proposed subzone area is situated in high quality native forest and bounded by an endangered species habitat, only 25% of the total flora and fauna habitat in the Kahaualea area has been proposed for subzone designation.

Site development may impact the endangered O'u habitat and native forest, but with careful planning and minimal removal of vegetation and trees, development activities should not significantly threaten existing flora and fauna.

Compatibility with Land Uses. The proposed subzone area is situated within LUC classified "conservation, limited" land. While geothermal development is considered to have a significant impact, each area within the conservation district has permitted uses. In each of these subzones, Protective, Limited, Resource, and General, the use of the area for "monitoring, observing and measuring natural resources" is allowed. In addition, the use of lands within a conservation district in which "governmental use not enumerated herein where public benefit outweighs any impact on the conservation district" is permitted. In this respect, geothermal related activities can be allowed in a conservation district and the development of these resources lead to widespread public benefit.

Utilizing buffer zones, the Hawaii Volcanoes National Park and the Natural Area Reserve has been excluded from the proposed subzone. In addition, mitigation measures will be required in the conservation district before geothermal development is permitted.

Economic Impact. Geothermal development within the proposed subzone will generate added income and create additional jobs. The need for additional housing to accommodate new workers should benefit the local construction industry.

Most importantly, geothermal development activities will promote energy self-sufficiency and reduce the State's dependency on imported oil.

Kilauea Southwest Rift, Hawaii

Potentials for Production. On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater chemical anomalies, it was estimated that there was a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. Based upon available information, it is uncertain as to whether developers would drill within the Pahala resource area.

Geologic Hazards. Historic lava flows have occurred in Kilauea's southwest rift zone in 1823, 1868, 1919, 1971, and 1974. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. There may be some danger from tsunami and ground subsidence in coastal areas. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa an Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Preservation of the natural setting can be achieved through careful planning and mitigation measures. Geothermal development should have little impact on aesthetics in the potential resource area.

Environmental Impacts. The impact of geothermal development to the environment will be in the area of air quality. This impact is expected to be minimized by current abatement technology.

Compatibility with Land Uses. The assessed resource area is currently classified as "conservation, resource" and "agriculture" by the State Land Use Commission. Potential impacts that may occur from geothermal development can be mitigated by careful planning and siting.

Economic Impacts. Geothermal development in the resource area will provide a measure of self sufficiency, reduce oil imports and bring added income and new jobs.

Mauna Loa Northeast Rift, Hawaii

Potentials for Production. Based on available data it was estimated that there was a 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in the resource area.

Geologic Hazards. Historic lava flows have occurred in Mauna Loa's northeast rift zone in 1852, 1855, 1880, 1899, 1935, 1942, and 1984. Eruptions (and associated hazards of ash fallout, ground deformation, cracking etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Geothermal development should have little impact on aesthetics in the resource area. In addition, preservation of the natural setting can be achieved by proper planning and mitigation measures.

Environmental Impacts. There would be a potential impact upon the environment in the areas of air quality and noise. These conditions are expected to be mitigated by utilizing current technological equipment to muffle and filter.

Any development in the resource area may have an impact on the existing flora and fauna. Some 60% of the assessed resource area consists of Category 1 forests, "exceptional native forest; closed canopy, with over 90% native cover". The forest area also provides habitat for various endangered bird species: Hawaiian Creeper, Akepa, Akiapola'au, 'O'u, and the Nene. This impact is expected to be minimized by proper planning and current abatement technology.

Compatibility with Land Use. Some 75% of the assessed resource area is presently classified as "conservation, protective" lands under the State Land Use District Classification. Geothermal development is expected to have some potential impact that can be mitigated by careful planning and proper siting.

Economic Impact. Geothermal development activity in the potential resource area should enhance employment. Additional housing may be needed to accommodate new workers.

Mauna Loa Southwest Rift, Hawaii

Potentials for Production. On the basis of historic volcanic eruptions, seismic activity and taking into consideration the absence of any other significant geophysical or geochemical anomalies, it was estimated that there was a 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in this resource area.

Geologic Hazards. Historic lava flows have occurred in Mauna Loa's soutwest rift zone in 1868, 1887, 1907, 1916, 1919, 1926, and 1950. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are espected to occur within this area in the future but the precise time and place is unpredictable. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Geothermal development within the assessed resource area is expected to cause potential changes in the aesthetics, lifestlye, culture and community setting. The impact of development activities should be minimized by proper planning and mitigation measures.

Environmental Impacts. There would be a potential impact on the air quality from geothermal resource development. In addition, impacts may occur on the fauna in this area. Approximately 50% of the resource area encompasses endangered bird species (Akepa, Akiapola'au and the Hawaiian Creeper) and mitigation measures must be implemented before development can occur.

Compatibility with Land Use. The assessed resource area is currently classified by the State Land Use Commission as "conservation limited" and "agriculture". Development activity may have potential impacts that can be mitigated by careful planning and proper siting.

Economic Impact. Employment should increase if geothermal development takes place within the area. The construction industry may benefit should additional housing be needed to accommodate new workers.

Hualalai Northwest Rift, Hawaii

Potentials for Production. Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologic age of vents along the upper rift and summit, there is an estimated 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in this resource area.

Geologic Hazards. The only historic eruption of Hualalai occurred in 1801. It produced two large flows covering 46 km^2 east and north towards the ocean. Several thousand earthquakes, from a source beneath Hualalai, shook the island in 1929. Eruptions and earthquakes (and associated cracking, fallout, subsidence, etc.) may occur here in the future but it is not possible to predict the precise time and place of future activity.

Social Impact. The impact on aesthetics in the resource area is expected to be mitigated by careful planning and siting.

Environmental Impacts. Approximately 10% of the resource area consists of Category 1 forest, "exceptional native forest with over 90% native canopy cover". The endangered fauna which inhabit the forest include the Alala, Hawaiian Creeper, Akepa and the Nene. Development in this area may have an impact on the flora and fauna. In addition, potential impacts may occur in the areas of air quality and noise. These impacts should be mitigated in order to minimize any adverse effects.

Compatibility with Land Use. The assessed resource area is currently classified as "conservation, protective & resource" under the State Land Use District Classification. Geothermal development in this resource area may have potential impacts that can be mitigated by proper siting and careful planning.

Economic Impact. Development activity in the geothermal resource area would create an increase in employment and additional housing may be required.

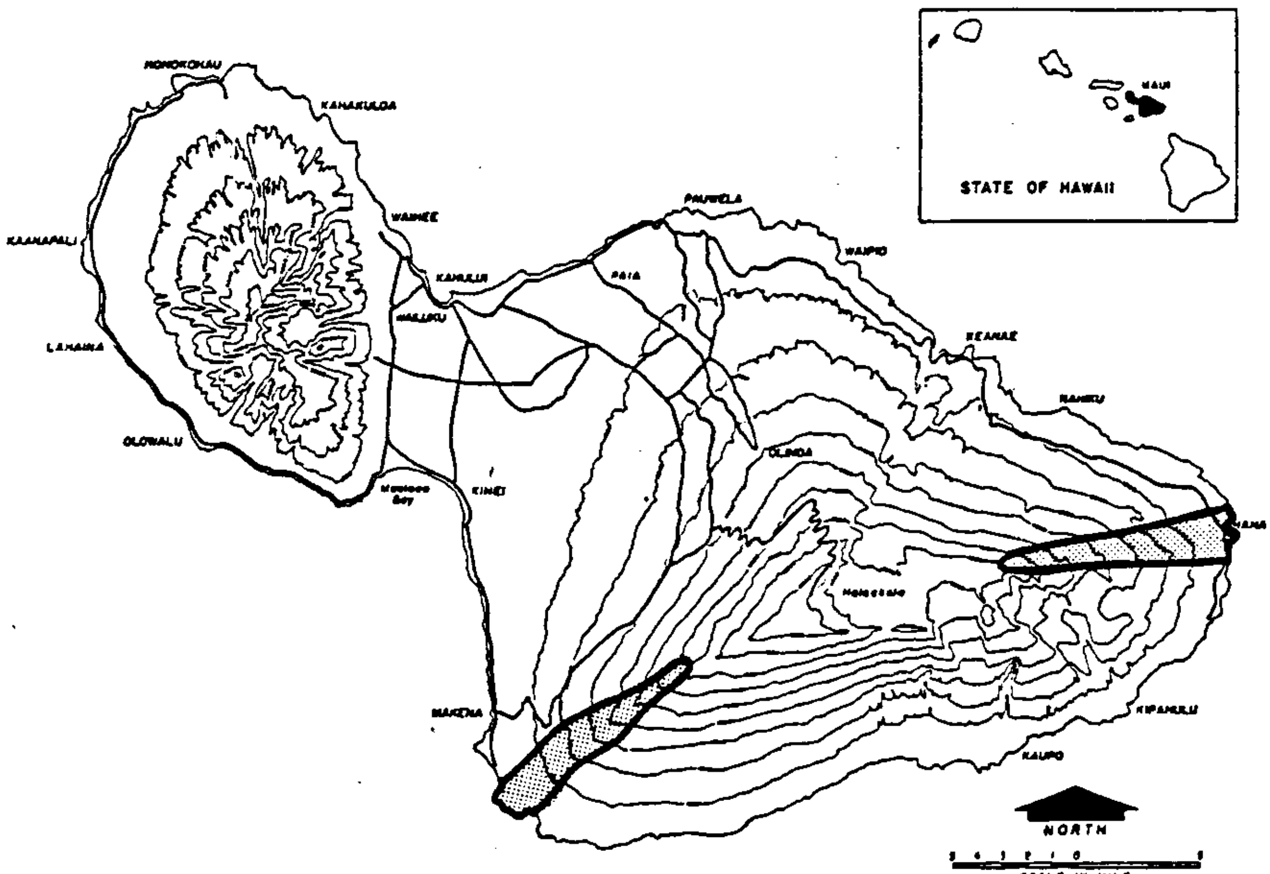
Haleakala Southwest Rift, Maui

Potentials for Production. Based on the historic 1790 eruption and results of deep resistivity soundings, it was estimated that there is a 25% or less chance of finding high a temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. Based upon developer interest and activity, the prospects for utilization of the proposed subzone area is good.

Geologic Hazards. Flows range from 200 to 20,000 years old. Six flows have erupted in this area within the last 1000 years. Based on past activity, the average rate of eruption is one per 150-200 years. The last flow occurred in 1790 by the coast; it was the largest (6 km^2) of the more recent flows. The risk from volcanic hazards includes dangers from lava flows and other attendant phenomenon such as pyroclastic fallout, cracking, subsidence, and swelling. There may be some danger from tsunami in coastal areas. The most recent earthquake near Maui occurred in 1938, 40 miles off the northern coast of East Maui. Haleakala's eruptive history suggests that an eruption could occur on Haleakala within the next hundred years. However, there is no way to predict a specific time or place of the next eruption.

Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety and productivity.



POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Maui

Figure 7.

Social Impacts. Geothermal development activities will have an effect on the lifestyle, culture and way of life for those residents living near Ulupalakua and Kanaio. The aesthetic impact of geothermal facilities within the proposed subzone must be minimized by careful siting, landscaping and architectural design. Mitigation measures will be required to protect the natural beauty and aesthetics of this area before geothermal development is permitted.

Environmental Impacts. Geothermal development in this area will be required to utilize abatement systems that meet the proposed State Department of Health air quality standards. Air quality within surrounding areas should not be impacted and little or no effects are expected on the existing flora and fauna habitats.

While air quality and noise will have an impact on the environment, these conditions are expected to be minimized and adverse conditions mitigated by using current technological equipment to muffle and filter.

Compatibility with Land Use. The assessed resource area is classified by the State Land Use Commission as "agriculture" and as "conservation, protective, general & resource". Any potential impact from geothermal development can be minimized by careful planning and mitigation measures.

Economic Impacts. Geothermal development within the proposed subzone area will provide a measure of energy self-sufficiency, reduce oil imports, bring about added income and provide additional jobs. In addition, the need for additional housing to accommodate new workers may benefit the local construction industry.

Haleakala East Rift, Maui

Potentials for Production. Based on the geologic age of the Hana Series lava flows, there is an estimated 25% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers within the Haleakala East Rift Zone.

Prospects for Utilization. It is uncertain as to whether developers would drill for geothermal resources in this assessed area.

Figure 8. EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE SUBZONE AREAS

Basis for Evaluation	Island of Hawaii						Island of Maui	
	Kilauea East Lower	Kilauea East Upper	Kilauea Southwest	Mauna Loa Southwest	Mauna Loa Northeast	Hualalai Northwest	Haleakala East	Haleakala Southwest
Potentials for Production	+90%	+90%	+90%	35%	35%	35%	25%	25%
Prospects for Utilization	good	good	uncertain	uncertain	uncertain	uncertain	uncertain	good
Geologic Hazards Impacts								
Lava Flows	x	x						
Pyroclastic Fallout								
Ground Cracks		x						
Ground Subsidence		x						
Earthquakes								
Tsunami								
Social Impacts								
Health								
Noise							x	x
Lifestyle, Culture, Community Setting				x			x	x
Aesthetics	x	x		x	x	x	xx	xx
Environmental Impacts								
Meteorology								
Surface Water								
Ground Water								
Air Quality	x	x	x	x	x	x	x	x
Flora and Fauna		xx		xx	xx	xx	xx	
Water Quality								
Culture and Archaeological Values								
Scenic and Aesthetic Values	x	x		x	x	x	x	xx
Recreational Values								
Compatibility of Development								
State Land Use Districts		xx			xx	xx	xx	
County Zoning								
Surrounding Areas								
Present Land Uses								
Economic Impacts								
Public Revenue Sources								
Public Service Costs								
Employment	x	x	x	x	x	x	x	x
Housing	x	x		x			x	x

Key:
+90%=greater than 90% 35%=35% or less 25%=25% or less x=moderate impact expected xx=significant impact expected

Geologic Hazards. The most recent flow on the east side of Haleakala is just north of the geothermal resource area between Olopawa and Puu Puou; it is about 500 years old. Based on past activity, the average rate of eruption is one per 10,000 years. The risk from volcanic hazards includes dangers from lava flows and other attendant phenomenon such as pyroclastic fallout, cracking, subsidence, and swelling. The most recent earthquake near Maui occurred in 1938, 40 miles off the northern coast of East Maui. There may be some danger from tsunami in coastal areas.

Social Impacts. The potential effects on lifestyle, culture, and the community due to geothermal development activities, as well as the impact on aesthetics is expected to be minimized. The visual impact of geothermal development can be mitigated by proper citing and planning.

Environmental Impacts. Air quality and noise may have an impact upon the environment. However, the effects on flora and fauna within the resource area will be minimized by utilizing mitigation measures. Approximately 50% of the area is Category 1 forest, "exceptional native forest, closed canopy with over 90% native cover". The forested areas provide habitat for three endangered forest birds: Maui Parrot bill, Crested Honeycreeper, and the Akepa.

Compatibility with Land Use. The assessed resource area is presently classified as "conservation, protective" under the State Land Use District Classification. Geothermal development in this area may have potential impacts that can be mitigated.

Economic Impacts. Development within the geothermal resource area will provide additional jobs for the community. Additional housing may be required to accommodate new workers.

CONCLUSIONS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

The assessment of Hawaii's geothermal resources involved the analysis of available scientific information. To initiate this activity the Department enlisted the help of a technical committee comprised of scientists in fields of geophysics, geochemistry, geology, engineering and hydrology. This committee conducted a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. Twenty separate areas were identified and studied. Of these, seven areas were identified and mapped as having high temperature geothermal resources of 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9840 feet. Five areas are located on the island of Hawaii and two on Maui. Five other areas in the State were identified as having low temperature geothermal resources of less than 125 degree celsius. These areas are located on the islands of Hawaii, Maui and Oahu.

Examination of the seven areas relative to social, economic, environmental, geologic hazards, and compatibility with land uses reveal several impacts that may result from the exploration, development and production of geothermal resources for electrical power generation. Weighting of the assessment factors was based upon a balance rather than a sequential priority as specified in Act 296, SLH 1983.

Considered also in the evaluation of impacts was the provisions of Chapter 226, the Hawaii State Planning Act. The statutory objective, "increased energy self-sufficiency" and statutory policies "accelerate research development and use of new energy sources" and "promote the use of new energy sources" were considered. Additionally, the State Energy Plan developed as one of the Hawaii State Planning Act's twelve Functional Plans specifies the need to develop alternate energy resources, including direct solar energy; indirect solar energy such as wind, hydropower potentials, biomass, and ocean thermal differences; and geothermal energy.

After evaluating the seven potential geothermal resource areas on the basis of resource availability, prospects for utilization, geologic hazards and examining the social, environmental, compatibility, economic concerns, and considering the statutory State energy objectives and policies; the following sites were determined as deserving consideration for designation as geothermal resource subzones by the Board of Land and Natural Resources:

Kilauea Lower East Rift, Hawaii
Kilauea Upper East Rift, Hawaii
Haleakala Southwest Rift, Maui

The above areas have the following common desirable elements for the exploration, development, and production of geothermal resource energy:

* potential for developing geothermal resources.
* interest in exploration, development and production of geothermal resource energy.
* commitment towards geothermal resource energy as a viable alternate energy source for Hawaii.
* advanced technology in geothermal resource development, such as emission control system, noise control systems, well and power plant designs, and safety provisions from lava flows, reduces the concerns for public health and safety.
* potential degradation to the environment has been fully investigated and mitigation measures considered.

RECOMMENDED SUBZONES

Based upon the assessment of geothermal poential in the State of Hawaii, the evaluation of social impacts, economic impacts, environmental impacts, geologic hazards and the compability with land uses, including community concerns and the state of technology in geothermal resource developments, it is recommended that the Board of Land and Natural Resources designate the Kilauea Lower East Rift, Island of Hawaii, Kilauea Upper East Rift, Island of Hawaii, and the Haleakala Southwest Rift, Island of Maui as geothermal resource subzones.

A description of the areas follows:

Kilauea Lower East Rift, Island of Hawaii

The area shown in Figures 1 and 2 identifies two separate sites--the Kapoho section and the Kamaili section. The probability of locating high temperature geothermal resources is estimated to be greater than 90 percent and the prospect for development and production of electrical energy is good. Relatively recent volcanic flows in the 1960's and 1970's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of geothermal resources.

The Kapoho Section, approximately 5939 acres lies adjacent to two subzones established by the Legislature in Act 151, SLH 1984. The extreme eastern end of the proposed Kapoho section is zoned in conservation due to relatively recent lava flows with the rest of the area zoned in agriculture. The northern boundary is buffered by a 2000-foot area where sensitive forest areas are located. The western end abuts Leilani Estates, a sparsely populated subdivision. The southern boundary generally follows the 90 percent resource probability line.

The area includes 279 acres of an existing Geothermal Resource Mining Lease R-4 issued to Puna Geothermal Venture.

The existing subzones are identified by Geothermal Resource Mining Lease R-2 issued by the Department of Land and Natural Resources for approximately 816 acres to Kapoho Land Partnership, subleased to Puna Geothermal Venture (Thermal Power Company, Dillingham, Inc. and Amfac) and Geothermal Resource Mining Lease R-3 issued to Barnwell Geothermal Corporation by the Department of Land and Natural Resources for approximately 769 acres. The two subzones are zoned agriculture by the State Land Use Commission.

The Kamaili Section comprised of 5519 acres, is entirely located in agricultural zoned lands. A Natural Area Reserve System (NARS) area is located west of the area and Leilani Estates lie to the east. The 90 percent probability line is to the south. A 2000-foot buffer area has been provided to separate the NARS area to the proposed Kamaili

Section and the conservation district lands lying to the southeast having high quality native forest serve to buffer a portion of the proposed Kamaili area from Leilani Estates.

Kilauea Upper East Rift, Island of Hawaii

This area of approximately 5300 acres shown in Figure 3 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to habitat the area and high quality native forest are located north of the rift zone. Other impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, intermittent volcanic activity centered at Puu O has been taking place in the proposed subzone area. The location of geothermal wells and power plants will be carefully sited on cooled or latent lava flows. When the current eruption activity has ceased, drilling and construction can take place at the risk of the developers. The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2000-foot buffer zone to both the Volcanoes National Park and the Wao Kele O Puna Natural Area Reserve. The proposed subzone area includes only a small portion of the natural forest and encroachment has been minimized to concentrate development activities towards the rift or volcanic flow areas. By limiting the range of the northern boundary, 75% of the potential resource area remains protected and maintained as high-quality native forest.

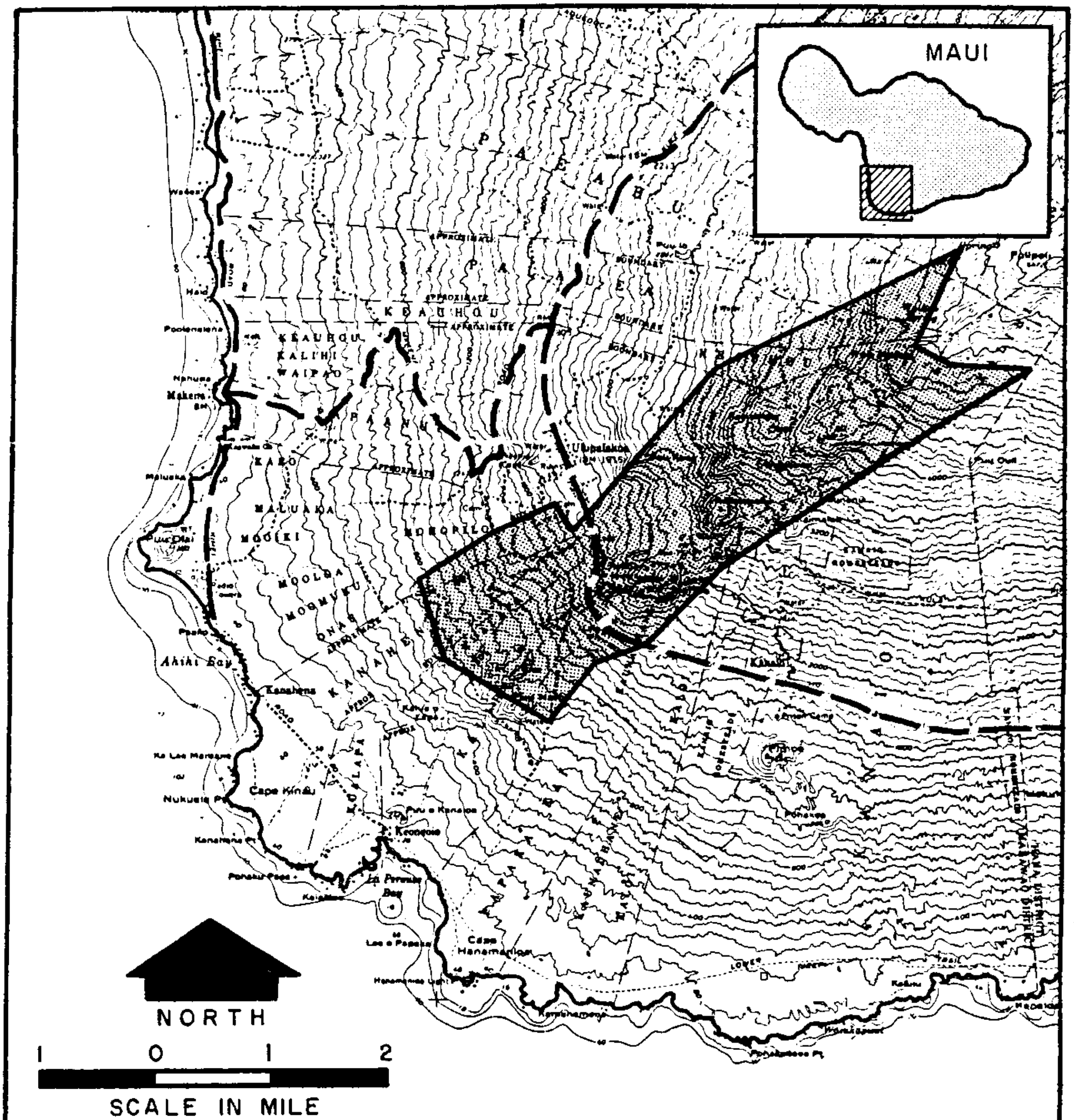
Other potential impacts may be mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

The area covering 4154 acres shown in Figure 4 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

Impacts expected are to scenic and aesthetic values. Impacts include noise, lifestyle, culture and community setting, air quality, employment and housing needs.

These impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

HALEAKALA SOUTHWEST RIFT

Island of Maui

Figure 9.

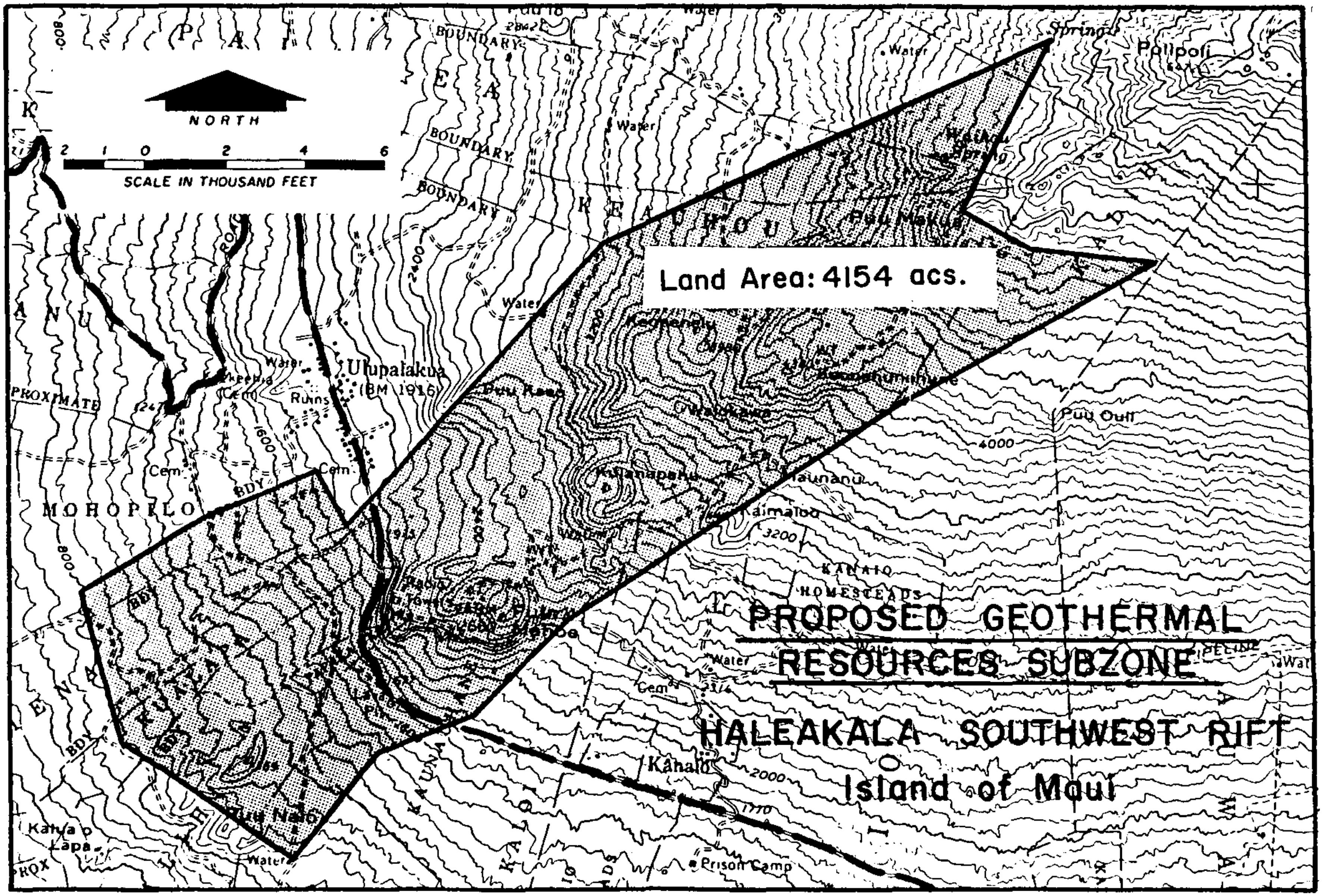
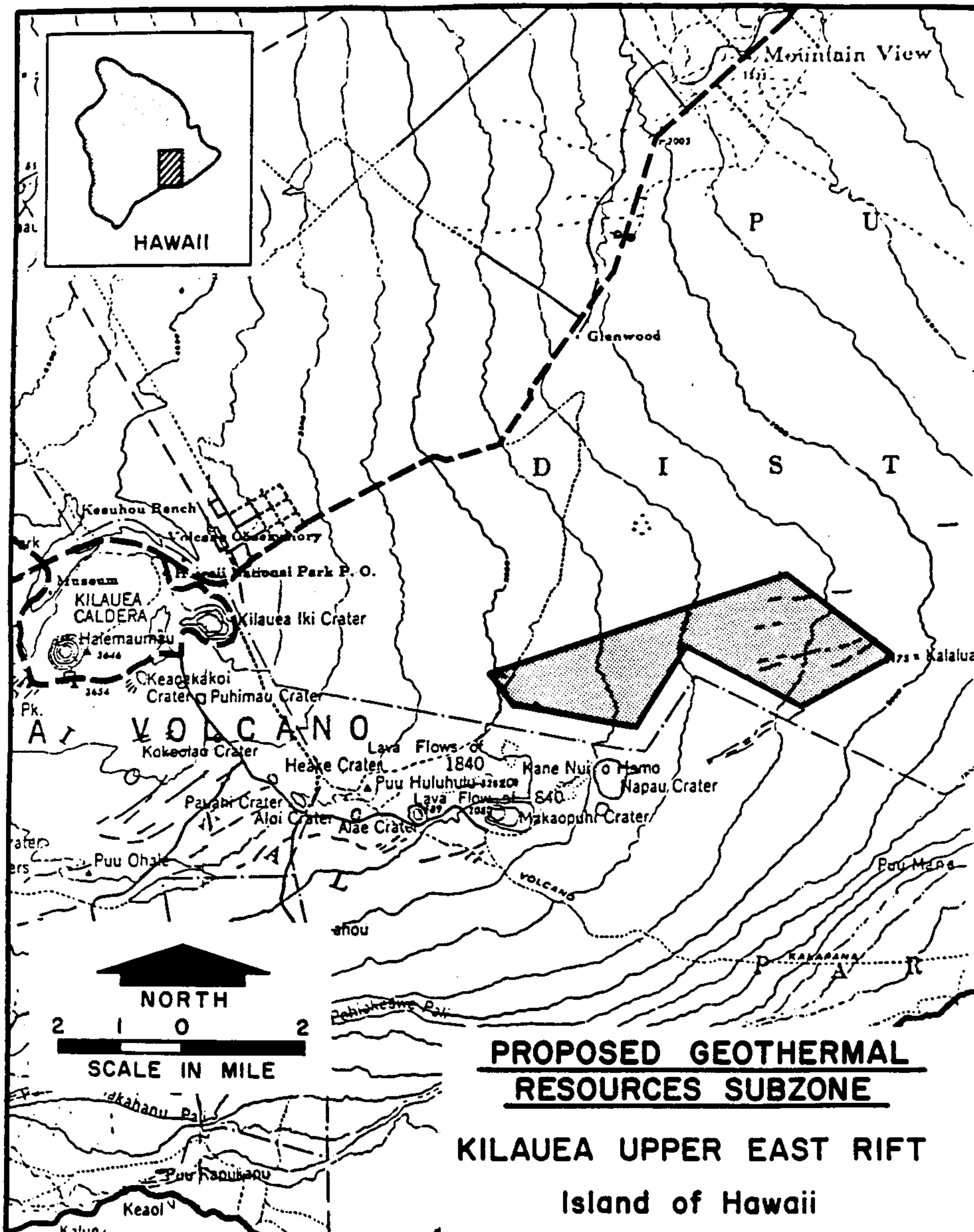

NORTH
2 1 0 2 4 6
SCALE IN THOUSAND FEET
Land Area: 4154 acs.
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
HALEAKALA SOUTHWEST RIFT
Island of Maui
Ulupalakua
(BM 1916)
Puu Ouli
Polipoli
Puu Makua
Kanaio
Kahalo
Prison Camp
MOHOPILO
KANAIO HOMESTEADS
BOUNDARY
Ruins
Cem.
Water
4000
3200
2400
2000
1600
800

Figure 10.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA UPPER EAST RIFT

Island of Hawaii

Figure 11.

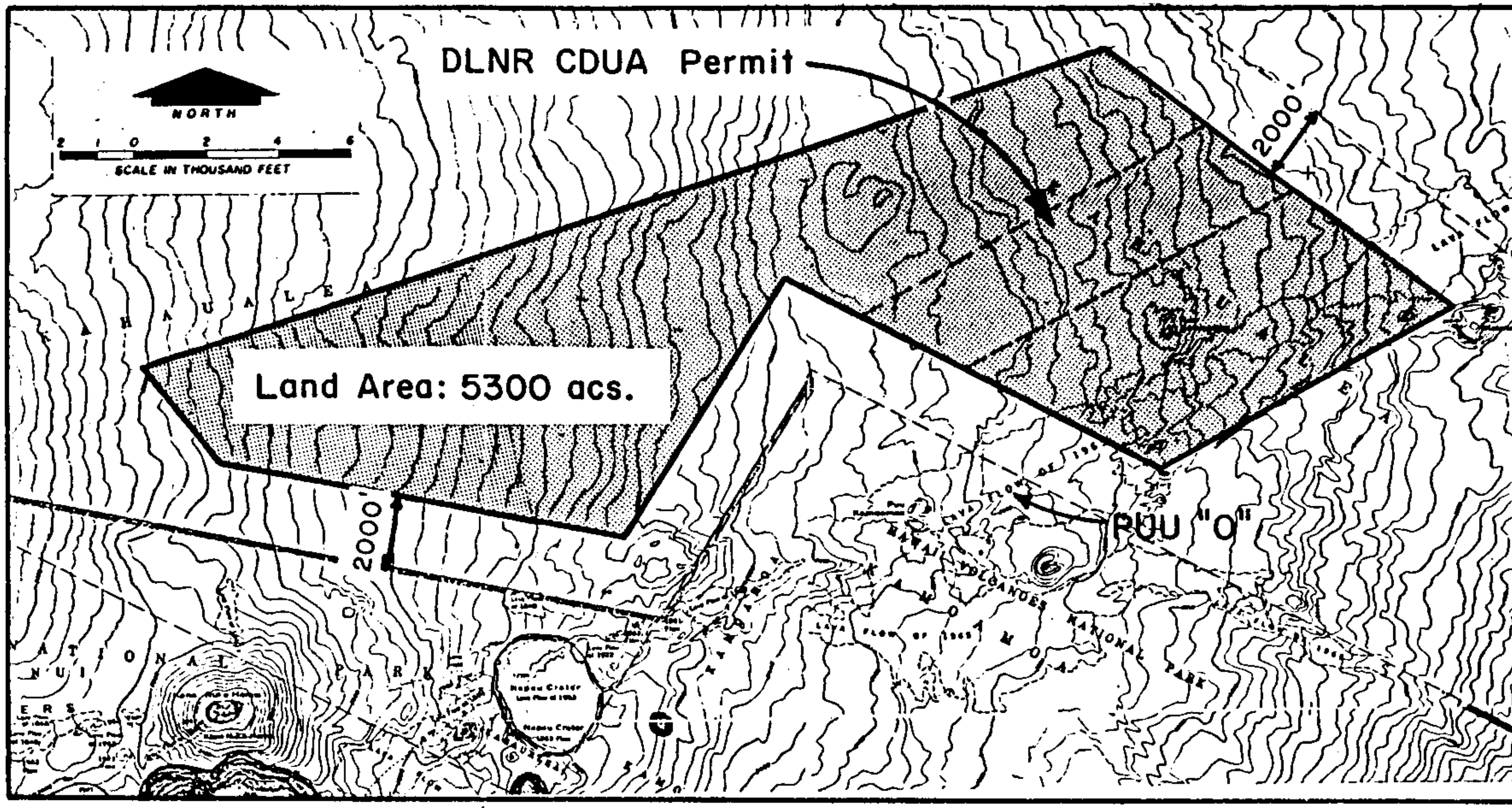


Figure 12.

PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA UPPER EAST RIFT

Island of Hawaii

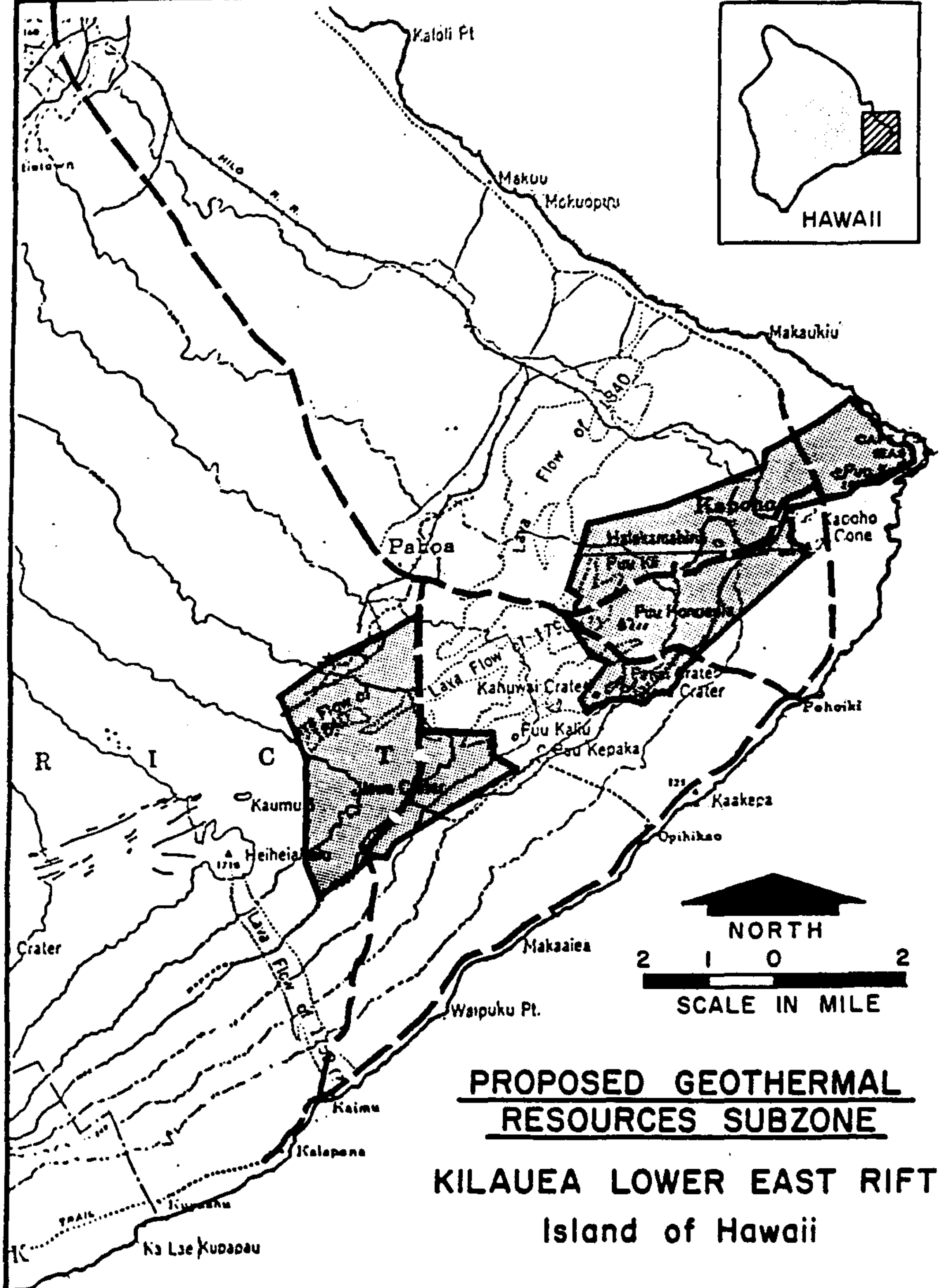

HAWAII
Kaloli Pt
Makuu
Makaukiu
Kapoho
Kapoho Cone
Pahoa
Kahuwai Crater
Puu Kaliu
Puu Kepaka
Pohoiki
Kaakepa
Opihikao
Kaumu
Heiheiahulu
Crater
Makaaiea
Waipuku Pt.
Kaimu
Kalapana
Ka Lae Kupapau
NORTH
2 1 0 2
SCALE IN MILE
PROPOSED GEOTHERMAL RESOURCES SUBZONE
KILAUEA LOWER EAST RIFT
Island of Hawaii

Figure 13.

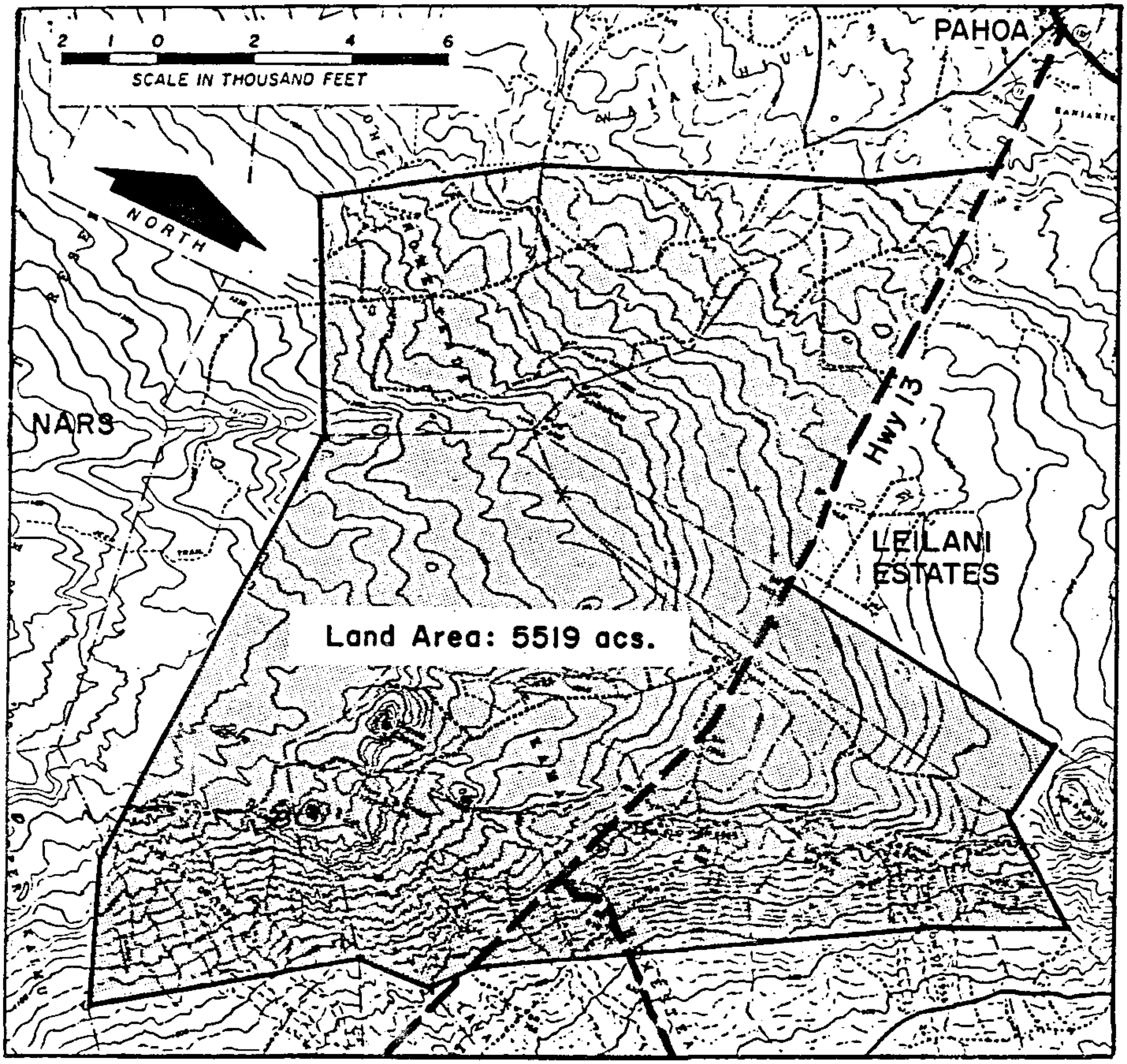
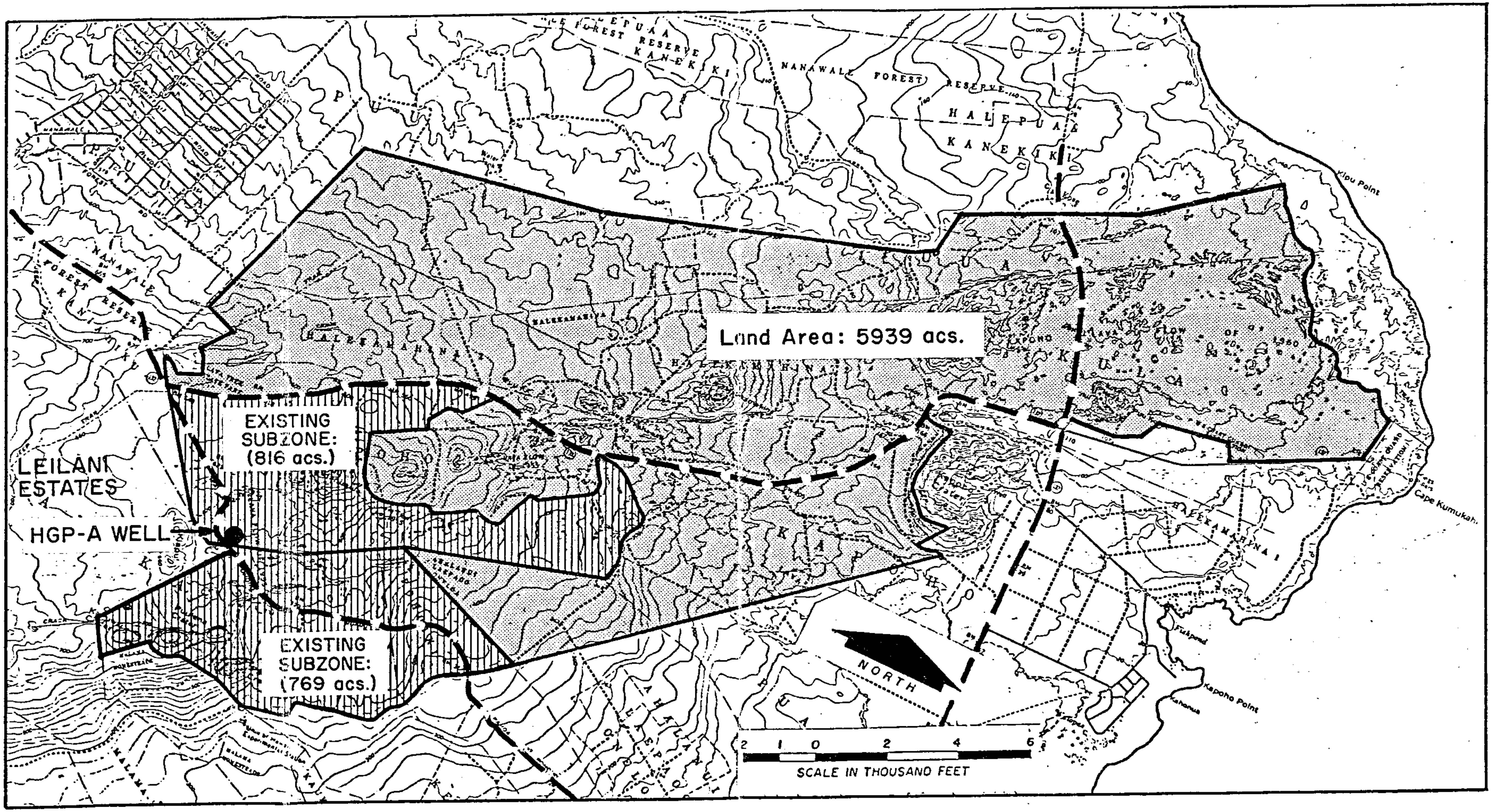


Figure 14.

PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT (KAMAILI SECTION)

Island of Hawaii



PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT (KAPOHO SECTION)

Island of Hawaii

APPENDIX A - ACT 296, SLH 1983

THE SENATE
TWELFTH LEGISLATURE, 19 83
STATE OF HAWAII

ACT 296

S.B. NO. 903
S.D. 1
H.D. 2
C.D. 1

A BILL FOR AN ACT

RELATING TO GEOTHERMAL ENERGY.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

SECTION 2. Section 182-4, Hawaii Revised Statutes, is amended to read as follows:

"§182-4 Mining leases on state lands. (a) If any mineral is discovered or known to exist on state lands, any interested person may notify the board of land and natural resources of his desire to apply for a mining lease. The notice shall be accompanied by a fee of $100 together with a description of the land desired to be leased and the

minerals involved and such information and maps as the board by regulation may prescribe. As soon as practicable thereafter, the board shall cause a notice to be published in a newspaper of general circulation in the county where the lands are located, at least once in each of three successive weeks, setting forth the description of the land, and the minerals desired to be leased. The board may hold the public auction of the mining lease within six months from the date of the first publication of notice or such further time as may be reasonably necessary. Whether or not the state land sought to be auctioned is then being utilized or put to some productive use, the board, after due notice of public hearing to all parties in interest, within six weeks from the date of the first publication of notice or such further time as may be reasonably necessary, shall determine whether the proposed mining operation or the existing or reasonably foreseeable future use of the land would be of greater benefit to the State. If the board determines that the existing or reasonably foreseeable future use would be of greater benefit to the State than the proposed mining use of the land, it shall disapprove the application for a mining lease of the land without putting the land to auction.

The board shall determine the area to be offered for lease and, after due notice of public hearing to all parties in interest, may modify the boundaries of the land areas. At least thirty days prior to the holding of any public auction, the board shall cause a notice to be published in a newspaper of general circulation in the State at least once in each of three successive weeks, setting forth the description of the land, the minerals to be leased, and the time and place of the auction. Bidders at the public auction may be required to bid on the amount of annual rental to be paid for the term of the mining lease based on an upset price fixed by the board, a royalty based on the gross proceeds or net profits, cash bonus, or any combination or other basis and under such terms and conditions as may be set by the board.

(b) Any provisions to the contrary notwithstanding, if the person who discovers the mineral discovers it as a result of exploration permitted under section 182-6, and if that person bids at the public auction on the mining lease for the right to mine the discovered mineral and is unsuccessful in obtaining such lease, that person shall be reimbursed by the person submitting the highest bid at public auction for the direct or indirect costs incurred in

the exploration of the land, excluding salaries, attorney fee's and legal expenses. The department shall have the authority to review and approve all expenses and costs that may be reimbursed."

SECTION 3. Chapter 205, Hawaii Revised Statutes, is amended by adding new sections to be appropriately designated and to read as follows:

"§205-   Geothermal Resource Subzones. (a) Geothermal resource subzones may be designated within each of the land use districts established under section 205-2. Only those areas designated as geothermal resource subzones may be utilized for the exploration, development, production, and distribution of electrical energy from geothermal sources, in addition to those uses permitted in each land district under this chapter.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205-   . The designation of geothermal resource subzones shall be governed exclusively by this section and section 205-   , except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein.

(c) The use of an area for the exploration, development, production and/or distribution of electrical energy from geothermal sources within a geothermal resource subzone shall be covered by the board within the conservation district and by existing state and county statutes, ordinances, and rules within the agricultural, rural, and urban districts, except that no land use commission approval shall be required for the use of subzones. The board and/or appropriate county agency shall, upon request, conduct a contested case hearing pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a

preponderance of evidence. Chapters 183, 205A, 226, and 343 shall apply as appropriate.

§205- Designation of areas as Geothermal Resource Subzones. (a) Beginning in 1983, the board of land and natural resources shall conduct a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal resource subzones. This assessment shall be revised or updated at the discretion of the board, but at least once each five years beginning in 1988. Any property owner or person with an interest in real property wishing to have an area designated as a geothermal resource subzone may submit a petition for a geothermal resource subzone designation in the form and manner established by rules and regulations adopted by the board. An environmental impact statement as defined under chapter 343 shall not be required for the assessment of areas under this section.

(b) The board's assessment of each potential geothermal resource subzone area shall examine factors to include, but not be limited to:

(1) The area's potential for the production of geothermal energy;

(2) The prospects for the utilization of geothermal energy in the area;

(3) The geologic hazards that potential geothermal projects would encounter;

(4) Social and environmental impacts;

(5) The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

(6) The potential economic benefits to be derived from geothermal development and potential related industries; and

(7) The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board shall consider, if applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226.

(c) Methods for assessing the factors in subsection (b) shall be left to the discretion of the board and may be based on currently available public information.

(d) After the board has completed a county-by-county assessment of all areas with geothermal potential or after

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any subsequent update or review, the board shall compare all areas showing geothermal potential within each county, and shall propose areas for potential designation as geothermal resource subzones based upon a preliminary finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Once such a proposal is made, the board shall conduct public hearings pursuant to this subsection, notwithstanding any contrary provision related to public hearing procedures.

(1) Hearings shall be held at locations which are in close proximity to those areas proposed for designation. A public notice of hearing, including a description of the proposed areas, an invitation for public comment, and a statement of the date, time, and place where persons may be heard shall be published and mailed no less than twenty days before the hearing. The notice shall be published on three separate days in a newspaper of general circulation state-wide and in the county in which the hearing is to be held. Copies of the notice shall be mailed to the department of planning and economic development, and the

planning commission and planning department of the county in which the proposed areas are located.

(2) The hearing shall be held before the board, and the authority to conduct hearings shall not be delegated to any agent or representative of the board. All persons and agencies shall be afforded the opportunity to submit data, views, and arguments either orally or in writing. The department of planning and economic development and the county planning department shall be permitted to appear at every hearing and make recommendations concerning each proposal by the board.

(3) At the close of the hearing, the board may designate areas as geothermal resource subzones or announce the date on which it will render its decision. The board may designate areas as a geothermal resource subzones only upon finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Upon request, the board shall issue a concise statement

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of its findings and the principal reasons for its decision to designate a particular area.

(e) The designation of any geothermal resource subzone may be withdrawn by the board of land and natural resources after proceedings conducted pursuant to the provisions of chapter 91. The board shall withdraw a designation only upon finding by a preponderence of the evidence that the area is no longer suited for designation, provided that the designation shall not be withdrawn for areas in which active exploration, development, production or distribution of electrical energy from geothermal sources is taking place.

(f) This Act shall not apply to any active exploration, development or production of electrical energy from geothermal sources taking place on the effective date of the Act, provided that any expansion of such activities shall be carried out in compliance with its provisions."

SECTION 4. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 5. If any provision of this Act, or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 6. This Act shall take effect upon its approval.

Approved by the Governor on JUN 14 1983

APPENDIX B - ADMINISTRATIVE RULES

Title 13, Department of Land and Natural Resources

Sub-Title 7. Water and Land Development

Chapter 184, Designation and Regulation of Geothermal Resource Subzones

Rules Amending Title 13, Administrative Rules

July 13, 1984

SUMMARY

Title 13, Administrative Rules, is amended by adding a new Chapter 184 entitled, "Designation and Regulation of Geothermal Resource Subzones".

TITLE 13

DEPARTMENT OF LAND AND NATURAL RESOURCES

SUB-TITLE 7. WATER AND LAND DEVELOPMENT

Chapter 184

Designation and Regulation of
Geothermal Resource Subzones

Subchapter 1. General

Subchapter 2. Designation of Geothermal Resource Subzones

Subchapter 3. Regulation of Geothermal Resource Subzones

Subchapter 1
General

§13-184-1 Purpose. The purpose of this chapter is to establish guidelines and procedures for the designation and regulation of geothermal resource subzones for the exploration, discovery, development, and production of geothermal resources for electrical energy production and distribution within conservation, agricultural, rural, and urban districts. These guidelines and procedures are intended to assist in designating areas which have potential for geothermal resource development for electrical energy production and which have an acceptable balance of the relationships of geothermal development to uses allowed in the land use classifications, to present uses of surrounding lands, to potential benefits, and to impacts. [Eff. Aug. 16, 1984 (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

§13-184-2 Definitions. As used in this chapter:

"Board" means the board of land and natural resources.

"Chairperson" means the chairperson of the board of land and natural resources or a designated representative.

"Department" means the department of land and natural resources.

"Geothermal resource" means the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, steam and associated gases, in whatever form, found below the surface of the earth.

"Geothermal resource subzone" means any area designated by the board as provided in this chapter for use of geothermal resource exploration, discovery, development, production, and distribution for useful purposes in addition to those uses permitted in each land district under chapter 205 of the Hawaii Revised Statutes.

"GRS" means geothermal resource subzone.

"Operator" means any person as defined herein engaged in drilling, maintaining, operating, producing or managing any geothermal well and appurtenances, geothermal research facility, and geothermal production or utilization facility including electric power plant. [Eff. AUG 16 1984] (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

§13-184-3 Subzone objectives. The establishment and regulation of geothermal resource subzones is intended to facilitate the exploration, development, and use of geothermal resources in those areas of the State where such activities will serve, in overall perspective, the best interest of the State, premised upon the criteria set forth in section 13-184-6. The major objectives are:

(1) To allow the utilization of geothermal energy for beneficial purposes, particularly electrical power generation, which would help achieve the State's goal of energy self-sufficiency and broaden the State's economic base through development of a natural resource;

(2) To allow geothermal exploration, discovery, development, production and utilization activities to potential or known geothermal areas of the State where such activities would be of greater benefit to the state than the existing or reasonably foreseeable future use of such areas; and

(3) To allow geothermal exploration, discovery, development, production and utilization activities to potential or known geothermal areas of the State which best demonstrate an acceptable balance among the criteria set forth in §13-184-6. [Eff. AUG 16 1984] (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

Subchapter 2
Designation of Geothermal Resource Subzones

§13-184-4 Board initiated subzone designation. Beginning in 1983, and prior to the designation of any area as a geothermal resource subzone, the board shall first make or cause to be made a county-by-county assessment of those areas within the State which have potential for geothermal exploration, discovery, development or production. The methods to be used for making the assessments shall be left to the discretion of the board, provided that the board shall as a minimum consider the criteria set forth in section 13-184-6. The board may in its discretion base its methods for assessment on currently available public information. Where applicable, the board shall consider the objectives, policies and guidelines set forth in part I of chapter 205A, HRS and the provisions of chapter 226, HRS.

The initial county-by-county assessments of areas with geothermal potential shall be revised or updated by the board at least once every five years beginning in 1988, or at any lesser interval of years at the discretion of the board. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-5 Landowner initiated subzone designation. In addition to designations initiated by the board, any property owner, geothermal mining lessee, or person with an interest in real property may initiate an application for designation of any area with geothermal potential as a geothermal resource subzone by specifying the area to the board. The application shall be accompanied by the following information:

(1) Names and addresses of the applicant, operator, owner of the geothermal mineral rights, landowner if not the same as the applicant, and the geothermal lease number, if applicable;
(2) Evidence and certification that the applicant is qualified to submit such a petition.
(3) An accurate description and map of the area desired to be designated as a geothermal resource subzone;
(4) A statement by applicant of the purpose, justification, and need for designation; and
(5) An assessment report based on the criteria set forth in section 13-184-6 and any other information to support the proposed designation.

Applications for geothermal resource subzones shall be submitted to the department for approval by the board. Each application shall be accompanied by a filing fee of $100.00. The chairperson shall review the application for completeness and may request additional information deemed necessary to process the application for board approval. The chairperson shall notify the applicant in writing of the acceptance of the completed application. Within 180 days of the written notification of acceptance of the application, the board shall publish notice of and hold public hearings and render a decision on designating any part or all of the area requested for designation as a geothermal resource subzone. If the request for geothermal resource subzone is denied, the board shall state its reason for its decision. If the board fails to hold a hearing and render a decision within 180 days after issuance of the notice of acceptance of the application, the application is deemed approved subject to the conditions of section 13-184-11. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-6 Criteria for designation of subzones. The board, in designating an area as a geothermal resource subzone, shall be guided by the selection of those areas that can demonstrate an acceptable balance among the criteria set forth below:

(1) That the area has known or plausible potential for the exploration, discovery, or production of geothermal resource;

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(2) That there is a known or likely prospect for the utilization of geothermal resources for electrical energy production and distribution.
(3) That any potential geologic hazards to geothermal production or use in the proposed area are examined.
(4) That any environmental or social impacts of the development of geothermal resources within the proposed area be considered;
(5) That the compatibility of development and utilization of geothermal resources within the proposed area is considered with other allowed uses within the area and within the surrounding lands;
(6) That the potential benefits to be derived from geothermal development and utilization in the proposed area be in the interest of the county or counties involved and the State as a whole.
[Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-7 Environmental impact statement not required. An environmental impact statement as defined under chapter 343, Hawaii Revised Statutes, shall not be required in assessing any area proposed for designation as a geothermal resource subzone. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-8 Notice and public hearings. When the board or a landowner proposes an area for designation as a geothermal resource subzone, the board shall hold a public hearing in reasonably close proximity to the proposed area and publish a notice of the public hearing setting forth:

(1) A description of the proposed area;
(2) An invitation for public comment; and
(3) The date, time, and place of the public hearing where written or oral testimony may be submitted or heard.

Such notice shall be published on three separate days in a newspaper of general circulation statewide and in the county in which the public hearing is to be held. The first publication shall be not less than twenty nor more than thirty days before the date set for the hearing. Copies of the notice shall be mailed to the state department of planning and economic development and the planning commission and planning department of the county in which the proposed area is located.

Publication of the notice of public hearing shall be considered sufficient notice to all landowners and persons who might be affected by the proposed designation.

The public hearing shall be held before the board and the conduct of the public hearing shall not be delegated to any agent or representative of the board. All persons and agencies shall be afforded the opportunity to submit data, views, and arguments whether orally or in writing. The department of planning and economic development and the affected county planning department shall be permitted to appear at the public hearing and make recommendations concerning the proposal to designate an area. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-9 Decision of the board. At the close of the public hearing, the board shall consider all the testimony and after deliberation make a decision to designate any portion, all or none of the proposed area or announce the date on which it will render its decision. The board may designate a proposed area as a geothermal resource subzone only if it finds the proposed area possesses an acceptable balance of the criteria set forth in section 13-184-6. If the board designates an area as a geothermal resource subzone it shall cause a notice of its decision to be published in a newspaper of general circulation statewide and in a newspaper of general circulation in the county in which the area is located and when so published its decision shall be final unless otherwise ruled invalid by a court of appropriate jurisdiction. Upon request, the board shall issue a concise statement of its findings and the principal reasons for its decision to designate a particular area. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-10 Modification and withdrawal of existing subzones. Modification of the boundaries or the withdrawal of an existing designated geothermal resource subzone by the board may be initiated by the board or by application of the appropriate County, landowner or person having a geothermal mining interest in the land. The procedure for modifying the boundaries or withdrawal of an existing designated geothermal resource subzone shall be conducted pursuant to the provisions of chapter 91, HRS; provided, however, that within an existing subzone with active geothermal exploration, development, production or use, the area may not be modified or withdrawn. An environmental impact statement as defined under chapter 343, HRS, shall not be required in assessing any modification of the boundaries or withdrawal of subzones. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

Subchapter 3

Regulation of Geothermal Resource Subzones

§13-184-11 Administration of subzones. Geothermal resource subzones designated by the board in any of the four land use districts; conservation, agricultural, rural, and urban shall be administered as follows:

(1) The board shall regulate the use of lands designated as geothermal resource subzones for geothermal resource activities that lie within conservation districts in accordance with chapter 205, Hawaii Revised Statutes and chapter 13-2, Administrative Rules of the department of land and natural resources.

(2) The appropriate county authority shall regulate the use of geothermal resource subzones that lie within urban, agricultural, or rural districts. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-12 Contested case hearings. A contested case hearing shall, upon request, be conducted by the board or the appropriate county agency pursuant to chapter 91 of the Hawaii Revised Statutes. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-13 Effective date and applicability. This chapter shall not apply to any active exploration, development or production of electrical energy from geothermal sources taking place on June 14, 1983, the effective date of Act 296, SLH 1983; provided further that any expansion of activities shall be carried out in compliance with the provisions of this chapter. Active exploration, development or production of electrical energy from geothermal sources on the effective date of Act 296, SLH 1983 includes those activities relating to exploration, development or production of electrical energy from geothermal sources permitted and approved on or before June 14, 1983. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

The amendment to Title 13, Administrative Rules, on the Summary Page dated July 13, 1984, was adopted on July 13, 1984, following public hearings held on Oahu, Hilo, Maui, and Kauai on May 22, 1984, after public notice was given in the Honolulu Star Bulletin on April 26, 1984; Hawaii Tribune Herald on April 26, 1984; Maui News on April 26, 1984; and The Garden Island on April 25, 1984.

These rules shall take effect ten days after filing with the Office of the Lieutenant Governor.

SUSUMU ONO, Chairperson
Board of Land & Natural Resources

Member
Board of Land & Natural Resources

GEORGE R. ARIYOSHI
GOVERNOR
STATE OF HAWAII

Dated: August 3, 1984

APPROVED AS TO FORM:

Deputy Attorney General

Filed

APPENDIX C - ACT 151, SHL 1984

THE SENATE
TWELFTH LEGISLATURE, 19 84
STATE OF HAWAII

ACT 151

S.B. NO. 2194-84
S.D. 1
H.D. 1
C.D. 1

A BILL FOR AN ACT

RELATING TO GEOTHERMAL ENERGY.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the rights of lessees holding geothermal mining leases issued by the state or geothermal developers holding exploratory and/or development permits from either the state or county government need to be clarified. The legislature finds that the respective roles of the state and county governments in connection with the control of geothermal development within geothermal resource subzones need to be clarified also. The purpose of this Act is to provide such further clarification.

SECTION 2. Section 205-5.1, Hawaii Revised Statutes, is amended to read as follows:

"[[]§205-5.1[]] Geothermal resource subzones. (a) Geothermal resource subzones may be designated within [each of] the urban, rural, agricultural and conservation land use districts established under section 205-2. Only those areas

designated as geothermal resource subzones may be utilized for [the exploration, development, production, and distribution of electrical energy from geothermal sources,] geothermal development activities in addition to those uses permitted in each land use district under this chapter. Geothermal development activities may be permitted within urban, rural, agricultural, and conservation land use districts in accordance with this chapter. "Geothermal development activities" means the exploration, development or production of electrical energy from geothermal resources.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205-5.2[.]; except that the total area within an agricultural district which is the subject of a geothermal mining lease approved by the board of land and natural resources, any part or all of which area is the subject of a special use permit issued by the county for geothermal development activities, on or before the effective date of this Act is hereby designated as a geothermal resource subzone for the duration of the lease. The designation of geothermal resource subzones shall be governed exclusively by this section and section 205-5.2, except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein. The provisions of this section shall not abrogate nor supersede the provisions of chapters 182 and 183.

(c) The use of an area for [the exploration,] geothermal development[, production and/or distribution of electrical energy from geothermal sources] activities within a geothermal resource subzone shall be governed by the board within the conservation district and, except as herein provided, by [existing] state and county statutes, ordinances, and rules not inconsistent herewith within [the] agricultural, rural, and urban districts, except that no land use commission approval or special use permit procedures under section 205-6 shall be required for the use of such subzones. [The board and/or appropriate county agency shall, upon request, conduct a contested case hearing

pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a preponderance of evidence.] In the absence of provisions in the county general plan and zoning ordinances specifically relating to the use and location of geothermal development activities in an agricultural, rural, or urban district, the appropriate county authority may issue a geothermal resource permit to allow geothermal development activities. "Appropriate county authority" means the county planning commission unless some other agency or body is designated by ordinance of the county council. Such uses as are permitted by county general plan and zoning ordinances, by the appropriate county authority, shall be deemed to be reasonable and to promote the effectiveness and objectives of this chapter. Chapters 177, 178, 182, 183, 205A, 226, 342, and 343 shall apply as appropriate. If provisions in the county general plan and zoning ordinances specifically relate to the use and location of geothermal development activities in an agricultural, rural, or urban district, the provisions shall require the appropriate county authority to conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91, on any application for a geothermal resource permit to determine whether the use is in conformity with the criteria specified in section 205-5.1(e) for granting geothermal resource permits.

(d) If geothermal development activities are proposed within a conservation district, then, after receipt of a properly filed and completed application, the board of land and natural resources shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether, pursuant to board regulations, a conservation district use permit shall be granted to authorize the geothermal development activities described in the application.

(e) If geothermal development activities are proposed within agricultural, rural, or urban districts and such proposed activities are not permitted uses pursuant to county general plan and zoning ordinances, then after receipt of a properly filed and completed application, the appropriate county authority shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether a geothermal resource permit shall be granted to authorize the geothermal

development activities described in the application. The appropriate county authority shall grant a geothermal resource permit if it finds that applicant has demonstrated by a preponderance of the evidence that:

(1) The desired uses would not have unreasonable adverse health, environmental, or socio-economic effects on residents or surrounding property; and

(2) The desired uses would not unreasonably burden public agencies to provide roads and streets, sewers, water, drainage, school improvements, and police and fire protection; and

(3) That there are reasonable measures available to mitigate the unreasonable adverse effects or burdens referred to above.

Unless there is a mutual agreement to extend, a decision shall be made on the application by the appropriate county authority within six months of the date a complete application was filed; provided that if a contested case hearing is held, the final permit decision shall be made within nine months of the date a complete application was filed."

SECTION 3. Notwithstanding the provisions of section 205-5.2, Hawaii Revised Statutes, regarding county-by-county assessment of areas with geothermal potential, the board of land and natural resources shall separately conduct an assessment of the area described on maps attached to the board of land and natural resources decision and order, dated February 25, 1983, which was the subject of a conservation district use permit. The assessment shall be in accordance with all provisions of Act 296, Session Laws of Hawaii 1983, regarding the procedures and standards for designation of an area as a geothermal resource subzone. The board of land and natural resources shall make its determination regarding the designation of all or any portion of the abovementioned area, as a geothermal resource subzone, on or before December 31, 1984.

SECTION 4. If any provision of this Act or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 5. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 6. This Act shall take effect upon its approval.

APPROVED MAY 25 1984

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APPENDIX D - GEOTHERMAL RESOURCE TECHNICAL COMMITTEE

The Geothermal Resource Technical Committee

MANABU TAGOMORI, P.E. (Chairman)
Engineer
Dept. of Land & Natural Resources
State of Hawaii

DONALD THOMAS, Ph. D.(Tech. Leader)
Geochemist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

BILL CHEN, Ph. D.
Engineer
Dept. of Computer Sciences
University of Hawaii - Hilo

DANIEL LUM
Geologist
Dept. of Land & Natural Resources
State of Hawaii

DALLAS JACKSON
Geophysicist
Hawaiian Volcano Observatory
U.S. Geological Survey

RICHARD MOORE, Ph. D.
Geologist
Hawaiian Volcano Observatory
U.S. Geological Survey

JAMES KAUAHIKAUA, Ph. D.
Geophysicist
U.S. Geological Survey
Honolulu, Hawaii

JOHN SINTON, Ph. D.
Geologist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

* * * * * * * * * *

Staff
Division of Water and Land Development

DEAN NAKANO, Geologist

JOSEPH KUBACKI, Energy Specialist

APPENDIX E - REFERENCES

REFERENCES

State of Hawaii, Department of Land and Natural Resources, September 1983, Plan of Study for Designating Geothermal Resource Subzones, Circular C-97.

______, ______, January 1984, Assessment of Available Information Relating to Geothermal Resources in Hawaii, Circular C-98.

______, ______, March 1984, Public Participation and Information Program for Designation Geothermal Resource Subzones, Circular C-99.

______, ______, March 1984, Geothermal Resource Developments, Circular C-100.

______, ______, June 1981, Rules on Leasing and Drilling of Geothermal Resources, Chapter 183 of Title 13, Administrative Rules.

______, ______, July 1984, Statewide Geothermal Resource Assessment, Circular C-103.

______, ______, July 1984, Social Impact Analysis, Circular C-104.

______, ______, July 1984, Economic Impact Analysis, Circular C-105.

______, ______, August 1984, Environmental Impact Analysis, Circular C-106.

______, ______, July 1984, Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas, Circular C-107.

______, ______, August 1984, Geothermal Technology, Circular C-108.